Petroleum
REFINER
FOR THE HYDROCARBON PROCESSING INDUSTRY

JANUARY 1961

A SPECIAL REPORT
Page 105

BETTER MAINTENANCE MANAGEMENT

Through ★ SCHEDULING ★ EVALUATING ★ SPRAYING
★ SAFETY ★ SANDBLASTING ★ STRESS RELIEVING

Rate Exchangers with Computers 147
Petrochemicals--Bright in 1961 161
When to Use Evaporative Cooling 165
How This Ammonia Unit Exploded 178
Latest Boxscore on Construction 209

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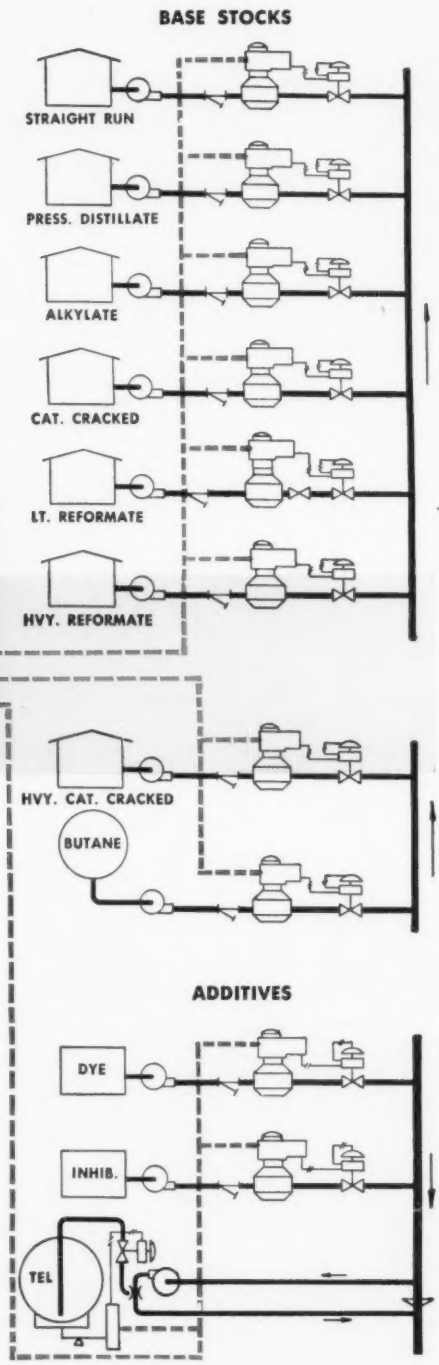

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Volume 40, No. 1 January 1961

SPECIAL MAINTENANCE REPORT

Title Page 103
Foreword 105
Daily Maintenance Scheduling 106
John J. Reagan
Shop Tester Checks Pneumatic Tools 116
Ray M. Kolb and Ralph H. Lange
Can You Measure Maintenance Performance? .. 123
Thomas B. Foster
Is Maintenance Safety Out of Hand? 129
David T. Smith
Tanks Can Be Sandblasted Safely While In Service 135
Holly P. Bradley
Stress Relieving Field Welds 139
W. J. Keough
Airless Spraying Vinyl Cuts Costs 42 Per Cent .. 143
Dwight L. DuPuy

OTHER TECHNICAL ARTICLES

Rate Exchangers This Computer Way 147
Donald L. Whitley and Ernest E. Ludwig
Applied Hydrocarbon Thermodynamics (Part 25) 157
Wayne C. Edmister
Petrochemical Outlook Bright for '61 161
Raphael Katzen
Now Consider Evaporative Cooling 165
F. Duncan Berkeley

AS MANAGEMENT SEES IT

Portrait of the Chief Executive 173
David Tver
This Ammonia Unit Exploded 178
Yoshio Sakai
Test Yourself on Labor Relations 182

DEPARTMENTS

Advertisers 304
Classified Ads 273
Construction ..... 190 & 209
Editorials 13
Equipment 274
How to Do It 184
Suppliers 261
Industry Quiz 21
Letters 102
Meetings 238
Men 241
News ..... 9 & 222
Readers' Service 305

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Petroleum
REFINER
FOR THE HYDROCARBON PROCESSING INDUSTRY
A Gulf Publishing Company Publication

A Quick Look

at this issue

These handy digests permit checking the articles you want to read first. ☑

SPECIAL MAINTENANCE REPORT

☐ **Daily Maintenance Scheduling . . .** "Reverting to a weekly schedule would be the equivalent of abandoning our welding machines and returning to riveted construction," said the chief scheduler at Sohio's Number 1 refinery in Cleveland, one month after the start of daily maintenance scheduling. For the most detailed description ever published on a daily scheduling system, turn to **Page 106.**

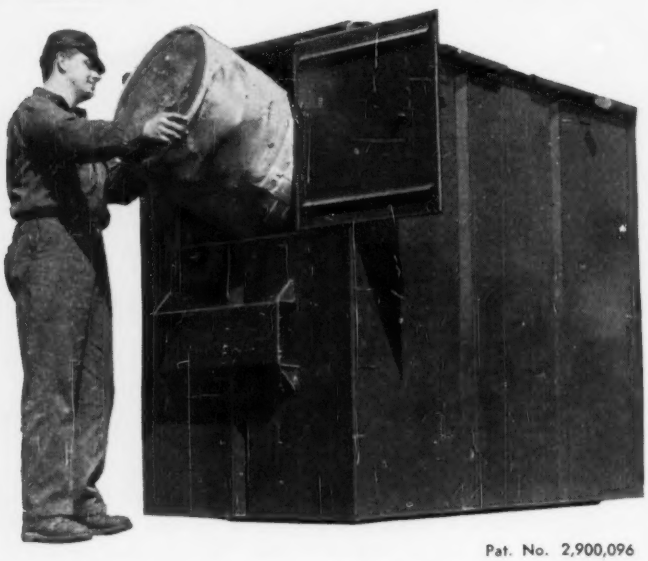
☐ **Shop Tester Checks Pneumatic Tools . . .** Developed at Standard of Indiana's Whiting refinery, this tester will save you maintenance manhours by checking tool defects before the job is started. The tests also provide a reliable method for comparing tools being considered for purchase, and simulate plant field conditions to check manufacturer's claim of quality. To see how the tester operates and how one can be built for your plant, turn to **Page 116.**

☐ **Can You Measure Maintenance Performance? . . .** Yes, but a simple formula does not exist. It must be made through a searching analysis of factors governing good maintenance. Check lists for the following categories will start you on the road to evaluating your maintenance performance: Organization, Operations, Industrial Relations, Planning and Scheduling, Work Load Control, Productivity Control, Preventive Maintenance, Purchasing and Stores, Engineering and Cost Control. To test your own department, turn to **Page 123.**

☐ **Is Maintenance Safety Out of Hand? . . .** The question is whether or not safety precautions required are out of proportion to the risk involved—thereby increasing maintenance costs unnecessarily. Also, what is the optimum maintenance safety level,

Please Turn Page ➡

How our small plant solved its waste disposal problem WITHOUT CAPITAL OUTLAY....



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Our small Midwestern manufacturing firm did not generate enough refuse to justify ownership of its own refuse disposal system. Yet, it was plagued by unsightly trash piles, fire hazards and scattered refuse in the plant yard.

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A Quick Look at This Issue . . .

and how do you get it? Because Du Pont is noted for its safety studies, the editors have asked one of its safety engineers to answer these questions. For their answers and to check on your own safety program, turn to **Page 129.**

☐ **Tanks Can Be Sandblasted Safely While in Service . . .** Tests show that sparks created by sandblasting are too cool to ignite flammable vapors. Heat build-up on the metal surface is well below the critical range of around 450° F. Very large amounts of static electricity can build up to greater than 30,000 volts. However, the tests conclude that if proper precautions are taken, static build-up and consequential dangerous arc formation will not occur. To see how to sandblast tanks in service safely, turn to **Page 135.**

☐ **Stress-Relieving Field Welds . . .** Commercial stress-relieving equipment for field welds may not be readily available. Here is a unique method of designing electrical resistance heating elements for use with welding machines and temperature recorders. This method will assure you good temperature control and accurate stress relief in the weld area. For complete details on how to design the system, turn to **Page 139.**

☐ **Airless Spraying Vinyl Cuts Costs 42% . . .** Particularly well suited for vinyl-base coatings, airless spraying will greatly decrease overspray and bounceback, which will almost double the amount of wet paint film deposited. Less solvent is needed, bringing the combined material saving to between 25 and 35 percent. A painter can increase his hourly production as much as 100 percent. Only one tenth of the volume of air is required compared to conventional systems. For details on how to use this system to cut your vinyl coating costs, turn to **Page 143.**

☐ **Rate Exchangers This Computer Way . . .** Digital Computers can take the tedious, repetitive labor out of heat exchanger design and give you a great deal more time for design evaluation. You will want to check over the computer program proposed in this informative article beginning on **Page 147.**

☐ **Applied Hydrocarbon Thermodynamics . . . (Part 25) . . .** This part of Professor Edmister's valuable series summarizes the previous 24 parts in concise terms. The author shows the areas that have been covered, and also indicates what will appear in future parts of this series. For a comprehensive recapitulation of the Edmister series, turn to **Page 157.**

☐ **Petrochemical Outlook Bright for '61 . . .** Because of entry into new areas and a late-1959 spurt of growth which should carry well into 1961, the over-all petrochemical industry looks bright indeed. To keep your petrochemical file up-to-date, don't miss this stimulating article beginning on **Page 161.**

☐ **Now Consider Evaporative Cooling . . .** Evaporatively cooled heat exchangers can sometimes be better than the air-cooled type, or designs requiring cooling towers. Be sure to look over the interesting applications and advantages set out in this article beginning on **Page 165.**

☐ **Portrait of the Chief Executive . . .** People harbor many false ideas about the chief executive of a typical company. To learn about the *real* man behind the desk—his needs, responsibilities, and what it takes to make him hit on all cylinders, don't miss this interesting and informative article beginning on **Page 173.**

☐ **This Ammonia Unit Exploded . . .** This intimate narrative takes you through a disastrous explosion at one of Japan's leading industrial plants. Kyowa Hakko Kogyo Co. pulls no punches in this blow-by-blow account of a blast that claimed 11 lives and racked up $694,000 worth of property damage. Turn now to **Page 178.**

Valuable Reading Ahead

One of the most popular series of articles to ever run in our "As Management Sees It . . . " department was "Applied Group Dynamics," which concluded in the December issue. Due to the requests for tear sheets of this series, Gulf Publishing Company's Book Publishing Division has decided to gather all of the information together and present it in hard-back book form. This book will be much more than just a compilation of the articles as they appeared in PR, for the authors have added information and completely indexed the book for your convenience. If you are a manager or supervisor, or if you ever have aspirations for such a position, you'll want this book.

Publication date is not scheduled until the second quarter 1961, but you can reserve your copy now by circling E-33 on the green card in the back of the book and sending it in today. You'll receive one of the first copies.

Another new book being prepared by Gulf's Book Division in conjunction with the editors of PETROLEUM REFINER is "Applied Hydrocarbon Thermodynamics," which will be based on Prof. Wayne Edmister's popular series, Part 25 of which appears on page 157 in this issue. For more complete information on this book plus how you can get your copy, turn to **Page 160.**

PETROLEUM REFINER'S Annual Index for 1960 . . .

appeared as a section in our December issue.

A limited number of separates has been provided and librarians and others who need them each may have a copy by addressing:

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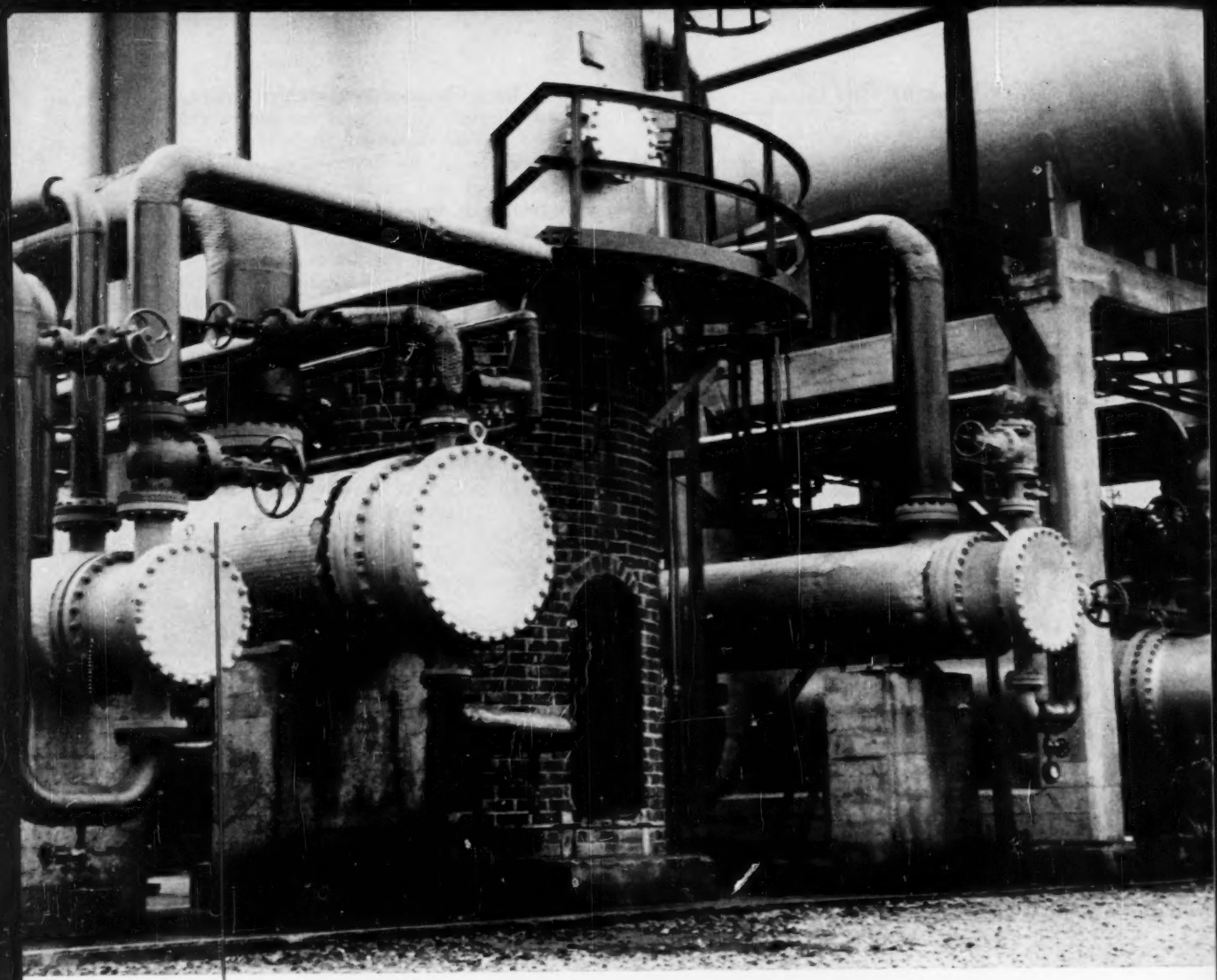

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Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, Ann Arbor, Michigan.

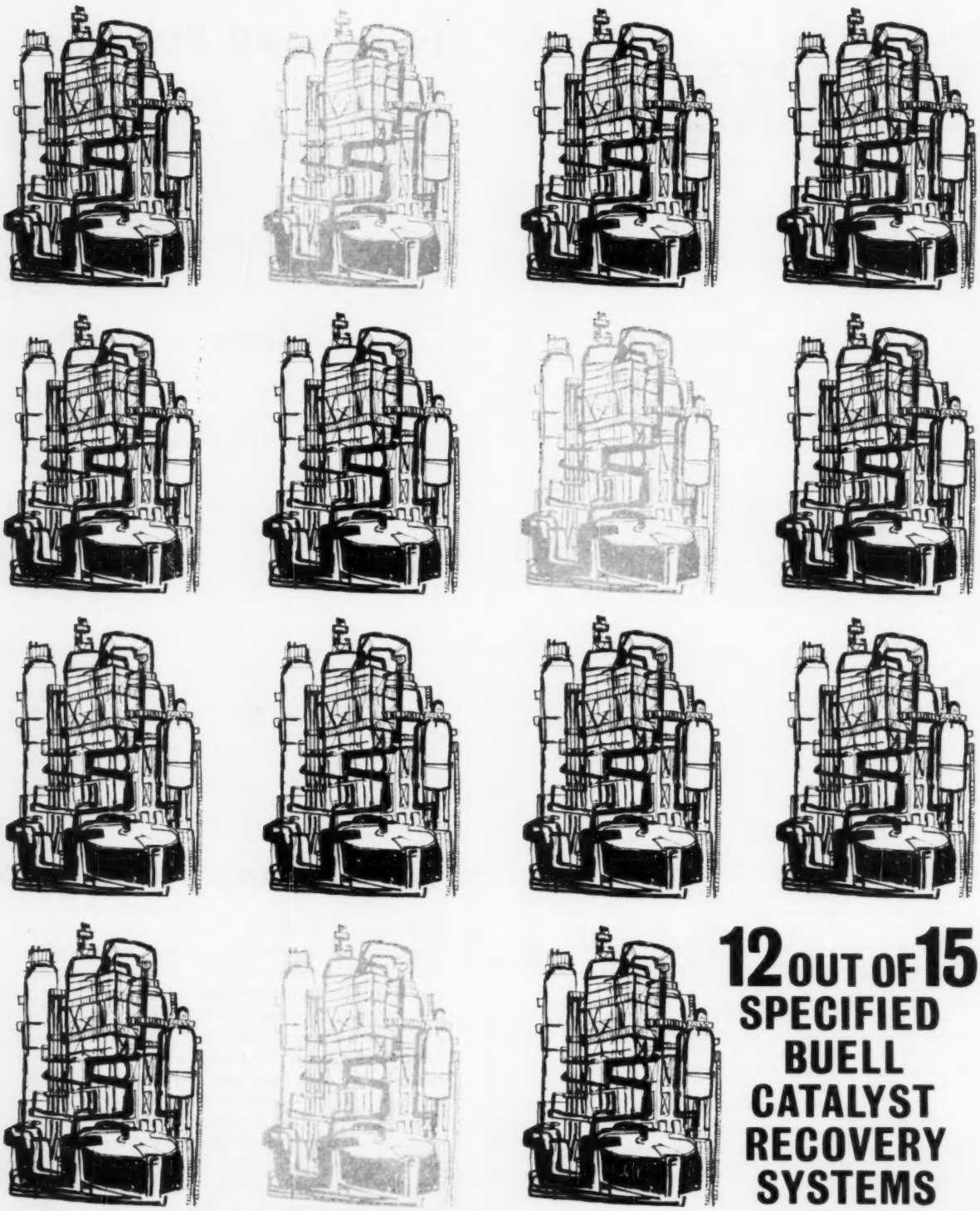
Help in PR Planning

MENTION WAS MADE last month of PR's annual editorial conference at which time a long and hard look was taken not only of what we've been doing during the past 12 months but, more important, of our '61 plans. Helping in these discussions—and theirs was a considerable contribution—were these five men each experienced in at least one HPI area (l to r): Phil Godshalk, plant superintendent, Bay Petroleum Co., Fulton, Texas; William G. Domask, head of industrial productions development section, Marketing Department, Humble Oil & Refining Co., Baytown, Texas; A. P. (Block) Olbrich, superintendent of maintenance, Phillips Petroleum Co., Bartlesville, Okla. J. S. Rearick, supervisor of design engineering, C. W. Nofsinger Co., Kansas City; and Larry Adee, general foreman, Lube Oil Division, Continental Oil Co., Ponca City Okla. At old Fort Clark, Texas, this fivesome offered ideas and suggestions which will over the coming months benefit virtually every PR subscriber So we say thanks to them not only for ourselves but for our big, worldwide family of readers.

Can Johnny Read?

YOU WHO READ word-for-word and at about the same rate regardless of purpose; those who do not know how to plan reading purpose, how to survey, skim or scan; those who have difficulty concentrating, who have to regress and re-read in order to get the meaning; or those who lack appreciation of the growing requirement and value of reading—those PR subscribers have a treatment as well as a treat in our issue for February. For therein will be found a "Rapid Reading" feature by the renowned Nila B. Smith of New York University's Reading Institute, who has put a few words together for the fellow who plods along at about 250 words per minute, whose desk always seemed piled sky-high with material that he never gets around to. And if the above description fits you, don't fret, because you are a "typical adult reader" and the Smith article was written for you.

PETROLEUM REFINER still has free for the asking reprints of Dr. James Fair's "How to Design Thermosiphon Reboilers," which appeared originally in our February 1960 issue. Address your request to Editorial Director, PETROLEUM REFINER, Box 2608, Houston 1, Texas.



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Quick Look at Industry...

Scanning Processes and Products . . .

More methacrylate on way via new process developed by Escambia Chemical. Ten years of development research and four years of market study result in commercial application of process, which sidesteps use of acetone and hydrogen cyanide used by Rohm & Haas and Du Pont. Look for new plant soon on Golden Gulf Coast . . . First commercial Catacarb plant for gas purification has been operating several months. Process involves conversion from existing hot carbonate unit for CO_2 removal—is being licensed by A. G. Eickmeyer, Prairie Village, Kan. Advantages claimed: higher gas-treating capacity, lower unit utility costs, elimination of sludge.

An all-organic, heat-resistant fiber that retains flexibility and part of its strength after exposure to intense heat announced by Minnesota Mining and Manufacturing. Available as fabric, it can be worked into laminates reinforced with high-temperature phenolic resin to form structural parts or molding compounds.

Engineering and the Unions . . .

After eight years, Engineers and Scientists of America folds. This federation of independent engineering and scientific unions wound up affairs last month. Reasons: money problems, engineers sensitive to union label, and weak organization structure. Straw that broke camel's back: loss of NLRB election at Western Electric early last year.

The Value of "Value Analysis" . . .

Du Pont says it saved $1 million in three-year program of testing material and equipment for purchase. Called "value-analysis," technique relates quality and cost of available brands, so company can get best value. Evaluation is done by company experts who also classify items by quality and price.

Keep Your Eye on Hydrazine . . .

Hydrazine due for price break, says Aerojet-General Nucleonics—and the rocket fuel can be made for as little as 25c a pound versus present $2. This proposed nuclear-fission product of ammonia has caused some skepticism, but no one says it's impossible. Next step: To convert batch process to continuous, study radioactivity of product, and look closely at production costs.

Merging the Old and Forming the New . . .

WPRA and NPA continue merger considerations as amalgamation extends from oil companies to organizations representing them . . . Anderson Pritchard stockholders approve sale of company to Union-Texas Natural Gas . . . Republic Oil Refining becomes division of Plymouth Oil . . . Jersey Standard sets up Esso Standard Eastern to take over refining, producing and marketing activities of Standard Vacuum, which will be dissolved. Newly formed Mobil Petroleum will also take over some StanVac functions . . . Kyushu Oil formed in Japan by Yawata Steel and others. Firm will build refinery on Kyushu Island by late 1962...Sid Richardson Refining properties and assets in Texas City sold to Texas City Refining.

Quick Look at Worldwide Construction . . .

Plans for new BP-Shell refinery in Nigeria to process 20,000 bpd of

Nigerian crude . . . Sun Oil to add $9.3-million gas plant at Marcus Hook, Pa., to replace two pre-World-War-II units . . . Montecatini completes design of 22-million-pound-per-year phthalic anhydride plant for Cengio, Italy . . . Union Carbide, Esso and two Swedish firms invest $40 million in Sweden's first petrochemical units—construction to start early this year . . . Humble's Enjay Co. will expand paraxylene capacity from 65 to 105 million pounds annually at Baytown, Texas . . . Austria's first major refinery comes on stream at Schwechat, near Vienna, with 32,000-bpd capacity . . . More about construction on pages 190 thru 220.

Quick Look Around the Nation . . .

Many larger oil companies awarding across board 5% wage increases for unrepresented employes . . . Federal Power Commission Chairman Kuykendall says most effective means to improve federal regulatory agencies is through permanent President's Conference on Administrative Procedure . . . Court approves Sun Oil's motion for directed verdict of aquittal on gasoline-pump price fixing charge, but same motion by 12 other defendent companies denied.

President of Asphalt Institute predicts 3% increase in sales of asphalt and road oils for 1960, compared with 1959 . . . U.S. Supreme Court refuses to block construction of Commerce Oil Refining's 43,000-bpd Naragansett Bay, R.I., refinery, which residents had said would be a nuisance.

The Big Picture of Fuel Policy . . .

England's Trades Union Congress to ask Prime Minister Macmillan for national fuels policy on grounds that growth in British oil demand will threaten payments position and lead to further contraction of British coal industry. Meanwhile, in U.S., Interstate Oil Compact Commission declares purposes of inquiry over national fuels policy aren't clear, warns such legislation could hurt oil and gas conservation program administered by member states of Compact.

The Supply and Demand Scene . . .

As curtain drops on 1960, petroleum product demand up 2.1% over 1959, much less than predicted at first of year. Gasoline gets most of blame, some industry experts attributing this to heavy taxes. The inventory picture: mixed trends—distillate and residual fuel oils down, gasoline and kerosine up.

Third Quarter Refining Profits Up . . .

Refiners, including integrated companies, report $755 million in net profits during third quarter, 1960, $77 million more than in coresponding 1959 period. Net profits also show increase from second-quarter 1960 total of $632 million. Third quarter sales were $7.52 billion.

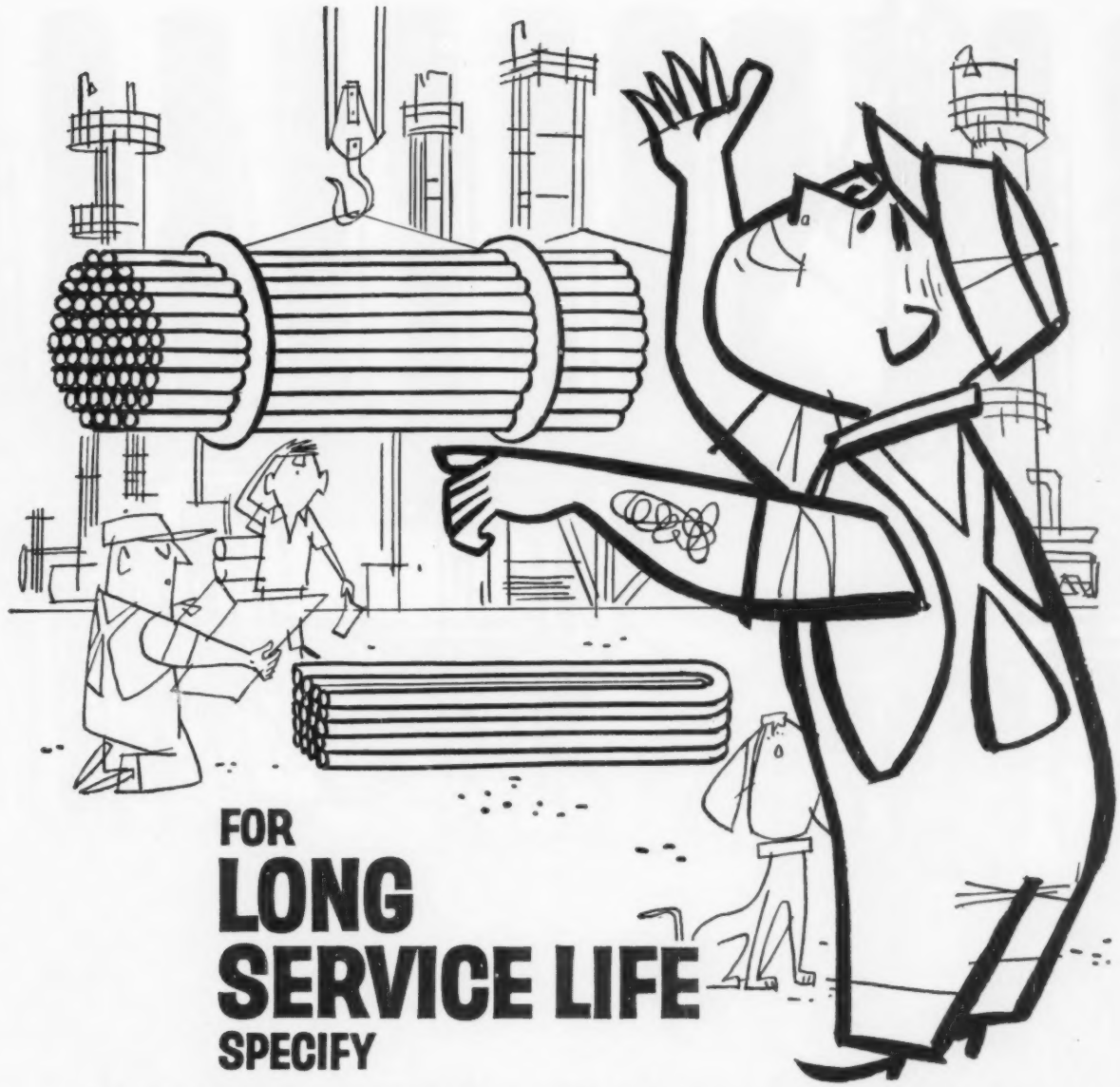
Soviet Technology for ICI? . . .

Imperial Chemical Industries may be close to making deal for sale of "technology" to Russia for manufacture of polyethylene, and for purchase of Soviet technique for making caprolactrun, the synthetic-fiber raw material. Soviet specialists would be trained in United Kingdom. Meanwhile, U.S.S.R. "Economic Gazette" urges Britian to purchase Soviet oil as means of enabling Russia to buy more British machinery and equipment.

Good News for Weed Choppers . . .

Man with the hoe may be disappearing in control of weeds, brush and unwanted grass because of herbicides, which show 7% growth over 1959. Pesticides have steady growth outlook of about 3%. Total pesticides amounted to $285 million at basic manufacturer's level in 1960.

■ Kellogg Engineering Teamwork at Work—on a 380,000,000-lb./yr. ethylene plant in Texas



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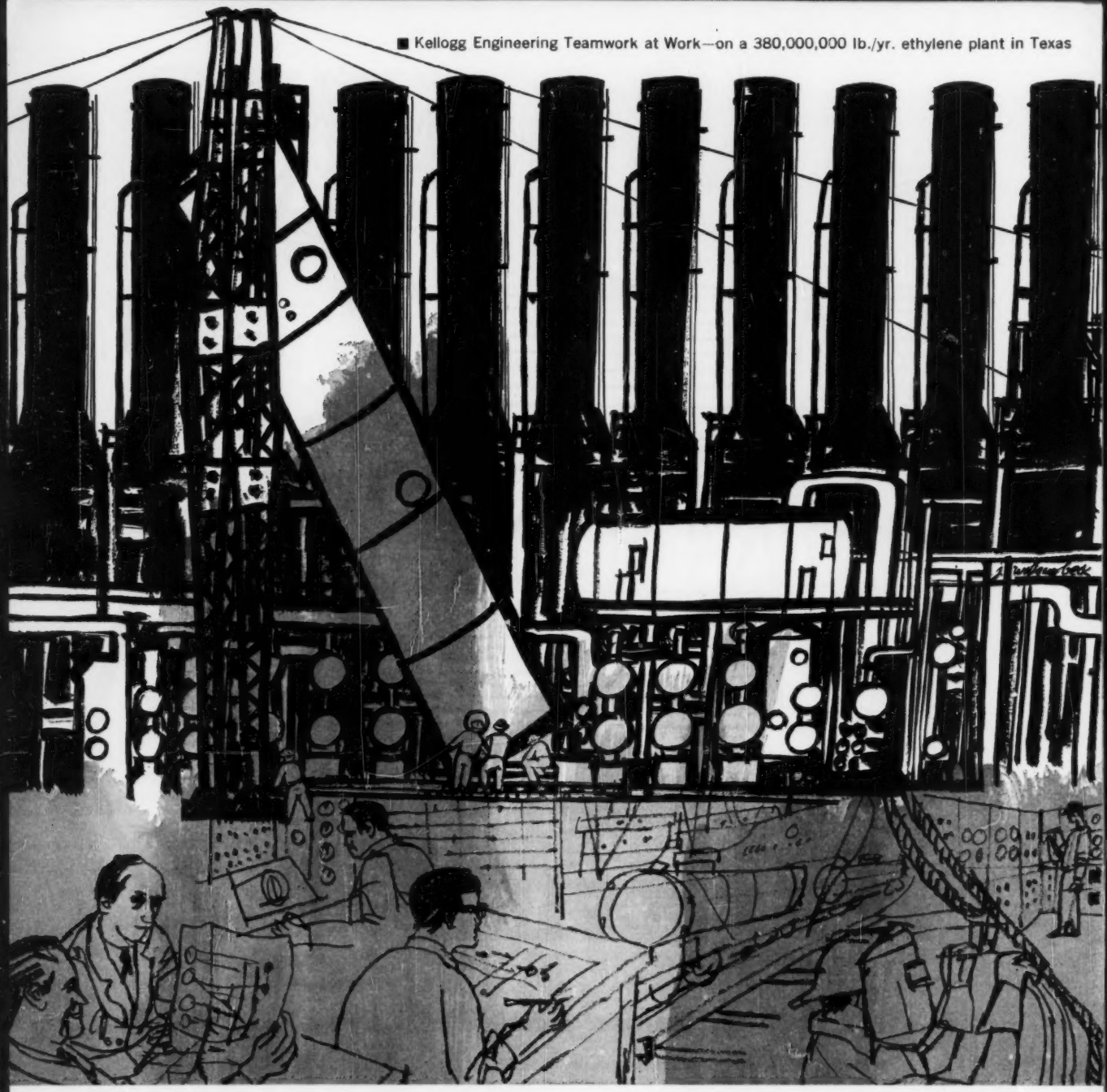
■ Kellogg Engineering Teamwork at Work—on a 380,000,000 lb./yr. ethylene plant in Texas



CHEMICAL PLANTS FROM SCRATCH

For many of the world's leading chemical and petrochemical firms, the Kellogg method of executing a capital investment in new plants and plant expansions has proved the soundest way to minimize expenditure.

This economic route to new chemical plants consists of coordinating and controlling all phases of engineering, procurement, and construction under an internationally integrated management. It is founded on close teamwork among all Kellogg operations at home and abroad . . . and with client engineering staffs.

Kellogg's method has improved process and plant engineering . . . saved money in procuring materials and equipment . . . increased labor productivity . . . expedited erection . . . achieved the earliest possible on-stream dates . . . and stayed within predetermined costs. The result is the plant which achieves the optimum balance of investment and operating costs.

Working with clients on this basis, Kellogg has been responsible for a variety of chemical plants throughout the world. In the United States, current projects include: a 380,000,000 lb./yr. ethylene plant in Texas; an 18,000,000 lb./yr. epichlorohydrin plant in New Jersey; a 300 ton/day ammonia plant in Missouri; a 200 ton/day urea plant in Delaware.

If you are planning to build new processing facilities in the U.S. or overseas, Kellogg would be glad to show you how its engineering teamwork could work to your company's advantage. Please address inquiries to The M. W. Kellogg Company, 711 Third Avenue, New York 17, N.Y.

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M KELLOGG W

Man Not a Slave to Tools

HOW MANY TIMES have you heard unthinking grumblings to the effect that new tools, new automated processes or equipment will replace workers? Some union chieftains especially like to pounce on this idea. Certainly they would not propose that the worker is a slave of the machine he operates. Yet, aren't these complaints tantamount to that proposition?

Machines Are Man's Slave. Clear thought would certainly dictate that tools are man's slave, that for man to do what a machine can reasonably do, and in many instances better, is a waste of man's talent. Thinkers would reason that one of the best ways for man to increase productivity in our already industrial world is through automation. Why then do many workers oppose this trend? Two reasons stand out:

Fear of Losing His Job. The first is the quite natural fear of losing his way of making a living. You too would undoubtedly feel fear if suddenly there was developed a machine to do your job as well or better than you can do it. You most likely would act just like the worker and scoff at the machine's abilities. But what would you do if the boss came into your office and convinced you that the machine wouldn't replace you but would instead allow you to accomplish much more during the hours you spend working for the company?

It's management's duty to calm this fear of losing a job by convincing the worker that his talents as the slave's master are needed—that by using the machine skilfully, in a master-slave relationship, the worker becomes much more valuable to himself, his company and mankind as a producer of goods than he could ever become through the use of his hands, his brain and a few simple tools.

Machines Increase Production But Tire the Operator. The second reason for opposition to tools and machines as a replacement for man's work is that they impose *more* fatigue on the worker's mind and nerves. A pneumatic chipping hammer is certainly no tranquilizer to a worker's emotional well being. This is where engineering designers and engineering purchasers get into the picture. They need to give more concern to the operator's emotions when designing machines to make his work more productive. Using lighter-weight materials, if the tool is hand held, will cut worker fatigue. Using sound deadening materials will greatly improve emotional dispositions by cutting out repetitive, deafening and unpleasant noise.

Equipment Is Often Ugly. Another major field for designers is that of eye appeal in our process plants. Certain sects in history, such as the Puritans, prided themselves in almost morbid hatred of beauty and pleasure. Others scorned comfort. Is inconvenience a virtue? Is ugliness a virtue? Answering these questions by themselves with no ifs, ands or buts, people today would shout a resounding "no." Yet these things are many times the rule rather than the exception in industry today.

In all refineries, petrochemical gas processing plants you can see equipment that is either downright ugly or so close to it that no one would call it a thing of beauty. Why is this done? Designers who sit at their stylized desks with tinted fluorescent light pouring over their shoulders too often think only of the functional part the equipment will play. They don't think much about beauty and the fact that some operator or maintenance worker will be looking at the "thing" for years. Their retort to such criticism is that they are engineers and not artists. Here management has the clear responsibility to demand better design from an eye appealing standpoint just as they demand the function of equipment to be improved.

Engineers are responsible for supplying tools to the industry. A blowdown tank is a tool, in a sense. How many beautiful blowdown tanks have you seen? Should not designers and specifiers start realizing that while functional equipment is a must, the everyday user of this equipment needs more than this? It would be hard to deny that a flour sack would function pretty well as a dress for your wife. The price is right and it would be simple to fabricate. But your wife and mine "need" more than a functional covering. They "need" the emotional boost they get by dressing up in eye appealing, as well as functional, clothes.

Most engineers can tell you if a woman's dress looks pretty or not, but few of them could design

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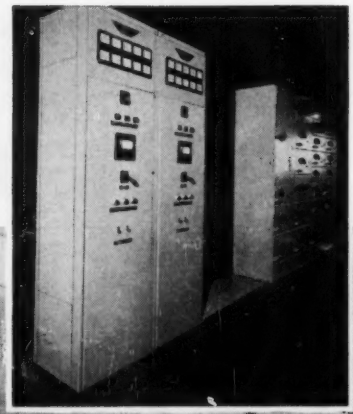

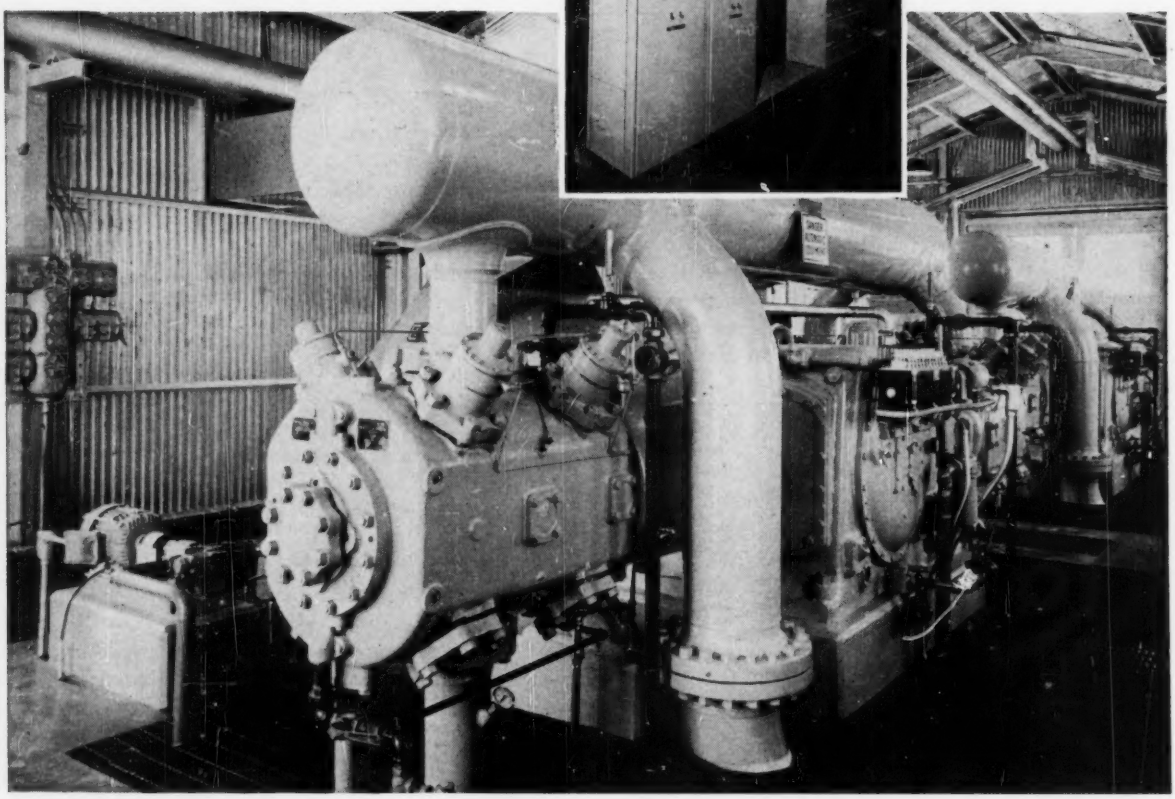

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one, even though they are trained in making drawings from ideas. Obviously they haven't been trained in the eye appealing aspects of design. The point is that they need to start training themselves to pay more attention to eye appeal in their designs. The opportunity for improvement is almost limitless.

More automated equipment will be added to plants but increasing demand for more and more products and production will require even more workers and at a higher level of skill and training. A two-pronged attack apparently is needed to eliminate the fear of automation and labor-saving equipment: (1) convince the worker *his* job is secure and (2) design equipment that is easy to use, less fatiguing and more eye appealing.

AEC Pays Training Costs

RADIOISOTOPES (radioactive forms of different chemicals, often man-made) are truly the success story of atomic energy, according to Paul C. Aebersold, director of isotopes development for the United States Atomic Energy Commission who spoke recently at the Winter Annual Meeting of The American Society of Mechanical Engineers in New York.

One of the valuable uses of radioactive tracers is to mark interfaces between batches of different petroleum products, such as gasoline and fuel oil flowing in the same pipeline. Leaks in oil and water lines and gas pipes can also be found through tracers.

Realizing that radiation in large amounts has the ability to affect material, manufacturers are now employing radioisotopes purposely in this way to improve certain qualities in products. Future uses of radioisotopes may include their use in plastics fabrication to give resistance to high temperatures and chemical agents like detergents, oils, acids and alcohols.

In general, however, industry has been slow in putting radioisotopes to use, Mr. Aebersold said. This may be due to the relatively few trained scientists, engineers and technicians that industry can draw on to expand radioisotopic applications, lack of familiarity, or inertia in using these new industrial tools, and the fact that, in many cases, the necessary technology has not yet been fully developed.

A part remedy to this situation was suggested at the same session of the ASME meeting by Paul J. Blaetus, chief of Isotopes Technology Training Branch of the Office of Isotopes Development, U.S. Atomic Energy Commission, Washington.

Blaetus described the AEC's Isotope Technology Program, which is "designed to assure the availability of trained personnel for the full exploitation of radiation techniques." A basic course in techniques is given at the Oak Ridge Institute of Nuclear Studies in Tennessee, lasting from two to six weeks, depending on individual interest and training. The full cost of the course, except for a nominal fee, is borne by the Atomic Energy Commission, he said.

Cheerful Word From the Courts

EARLY LAST MONTH the U.S. Supreme Court refused to block construction of a proposed 43,000-bpd refinery in Rhode Island. Local residents had opposed Commerce Oil & Refining Co.'s plans to construct the plant on the grounds it would be a nuisance. But the appellate court upheld Commerce Oil's right to build, and the Supreme Court refused to hear the case—thus leaving the lower court's ruling in effect.

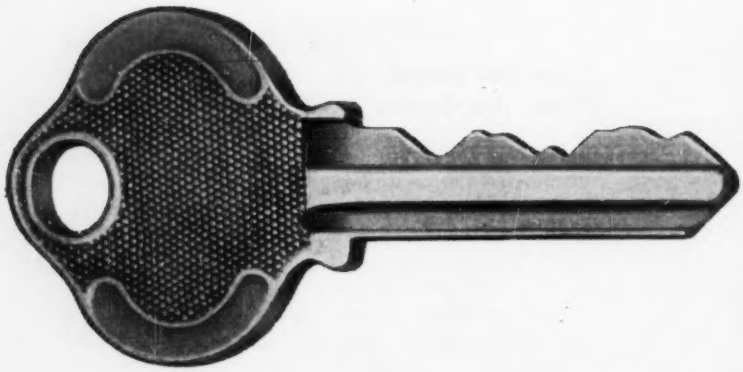
Refining companies can take solace in this favorable decision and similar ones that the courts have made in recent months. It appears there is emerging a relaxation of past restrictions on refining-type industrial activity. This theory is borne out by comparing the Commerce Oil decision with one by the Kentucky Court of Appeals. In this case, an injunction had been granted against operating of a Louisville Refining Co. plant on grounds it was a nuisance.

The facts in this case, which is currently being appealed, were almost identical to those in the Commerce Oil case, in which the appellate court held that ". . . to secure an injunction against a neighbor's prospective use of his property, more must be shown than the mere probability or possibility of harm resulting. Unless a *proposed* use is a nuisance in itself . . . courts of equity do not readily grant injunctions to restrain *anticipatory* nuisances."

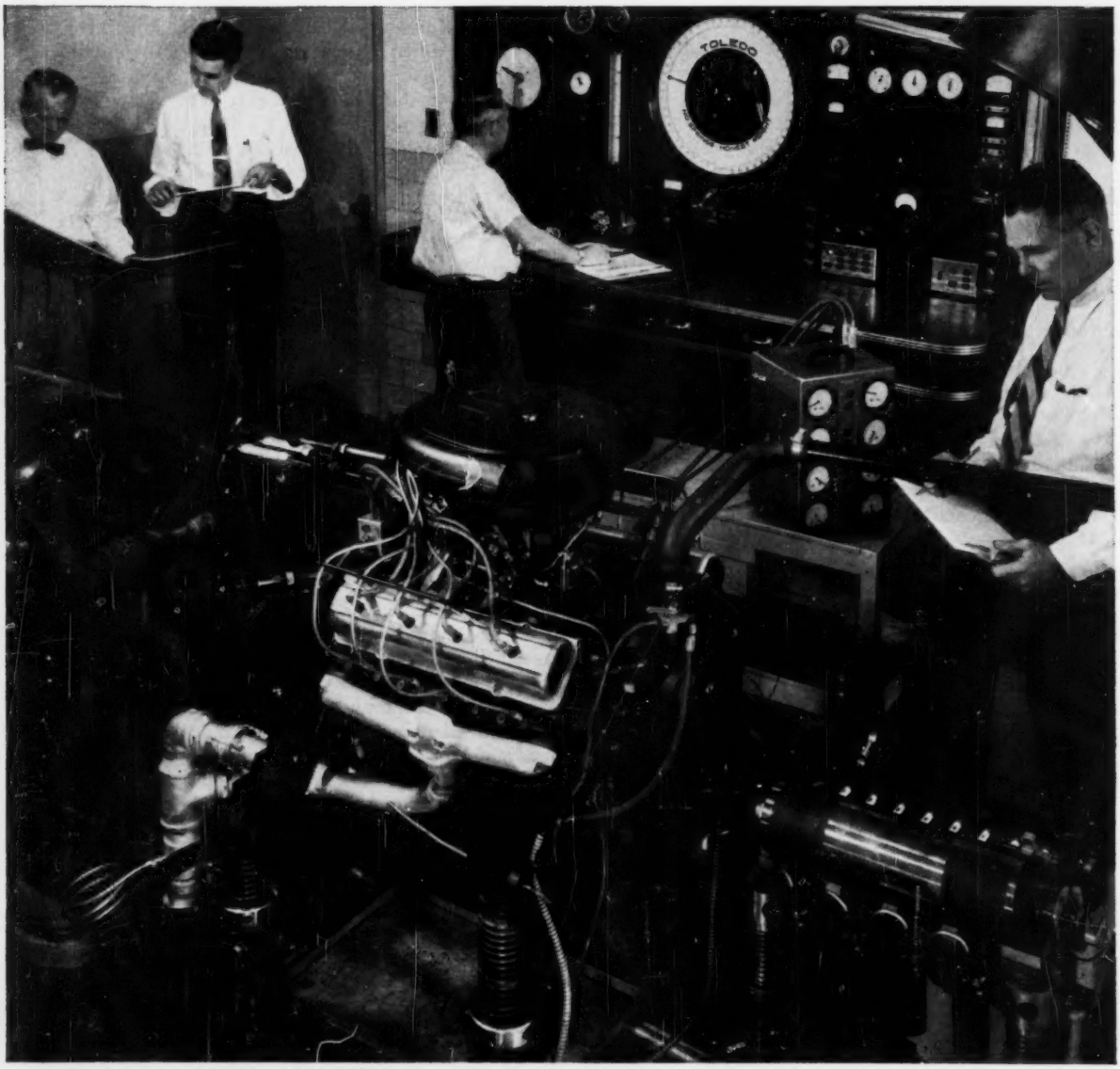
This same court held in its decision that refineries are not in the category of an illegal nuisance. It based its decision on a controversy of this character in a Montana court, where an action had been brought against the Cut Bank Refining Co. to enjoin erection of a refinery. Adjacent residents had complained of odors and the danger of fire and explosion from vapors. But the court held that "refining crude oil . . . is not a nuisance in itself—but a plant may become a nuisance *by the manner in which it is operated or constructed.*" The part of this decision referring to the manner of operation and construction should give all refining companies a real sense of self satisfaction. It is the realization of these very points that has prompted our forward-looking refining industry to install the finest equipment, assuring maximum protection of the community from air and water pollution.

Careful planning of clean, safe, modern refineries has finally brought American jurisprudence to the conclusion that before a firm may be prohibited from building or operating a plant it must first be shown that (a) the proposed construction or use to be made of the property will be itself a nuisance, or (b) that while it is not itself a nuisance, a nuisance *must necessarily* result from the contemplated thing or act (construction or operation).

The refiner need only continue seeing that the finest equipment is installed to assure safety from air and water pollution, and other dangers associated with the processing industry. If the HPI will follow this conviction, costly lawsuits over the nuisance issue should eventually disappear altogether.



COMPONENT ALLOCATION— A KEY TO BETTER ROAD PERFORMANCE



Ethyl-developed instrumentation and equipment used in studies of deposit effects.

SELECTING gasoline components and matching them with the multiple choice of antiknocks now available presents the refiner with a complex but rewarding situation. It can, in many cases, produce octane numbers at low cost or it can give a better road performing fuel at the same octane level.

For example, the substitution of paraffinic base stocks for aromatic stocks, while using increased TEL content to control octane level, can provide the refiner with a gasoline having superior road octane number. With lower aromatics he also gets better deposit effect characteristics.

Utilization of higher TEL concentrations makes the use of straight-run naphthas and natural gasolines particularly attractive to refiners who blend their premium gasoline almost entirely from light cracked stock and heavy reformate. Such gasolines are highly aromatic and extremely sensitive. The lower octane paraffins found in the straight-run and natural gasoline components are insensitive and very responsive to TEL.

Adding TEL and replacing all or part of the cracked stocks not only will decrease sensitivity and improve Road octane, but will permit less severe reforming. Reducing reformer severity produces less aromatics, more paraffins, better TEL response, and lower blend sensitivity. In contrast, severe reforming and resulting highly aromatic stocks may cause deposit problems in high compression engines.

TEST RESULTS

Deposit effect tests on two gasolines—one high in TEL, low in aromatics (Fuel A)—the other low in TEL, high in aromatics (Fuel B)—were run in a passenger car engine at 11-to-1 compression ratio under city-suburban driving conditions. The test fuels had similar volatilities, sulfur contents, and were reasonably close in laboratory octane numbers—the high-TEL fuel having the characteristic lower sensitivity.

	FUEL A	FUEL B
TEL content, ml/gal.	4	2
% aromatics	24	40
% olefins	11	5
Theories of phosphorus	0.3	0.3
Research octane number	102.0	102.8
Motor octane number	93.5	92.3
Stabilized octane number requirement*	102.0	103.0
Octane number requirement increase	3.5	4.1
Surface ignition*, number of counts per hour	0.5	6.2
Rumble occurrence, % of accelerations	0	80

*CRC reference fuels

Notice that after deposits had stabilized, the engine run on Fuel A had lower octane requirement, less octane requirement increase, and fewer occurrences of surface ignition and rumble.

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Antiknocks give you a Road octane bonus you can't get any other way.

Gasoline sensitivity can be decreased with antiknocks.

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Antiknocks can reduce or delay capital investment in octane improvement equipment.

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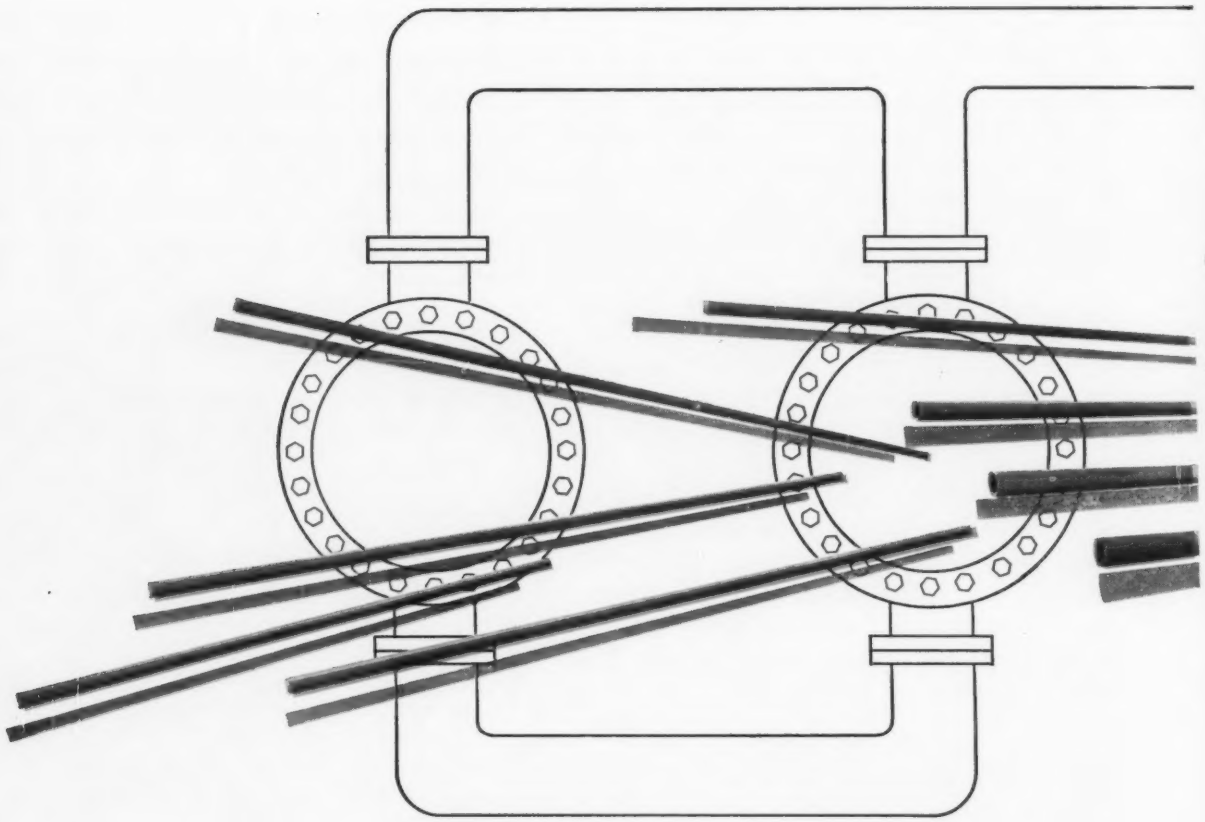

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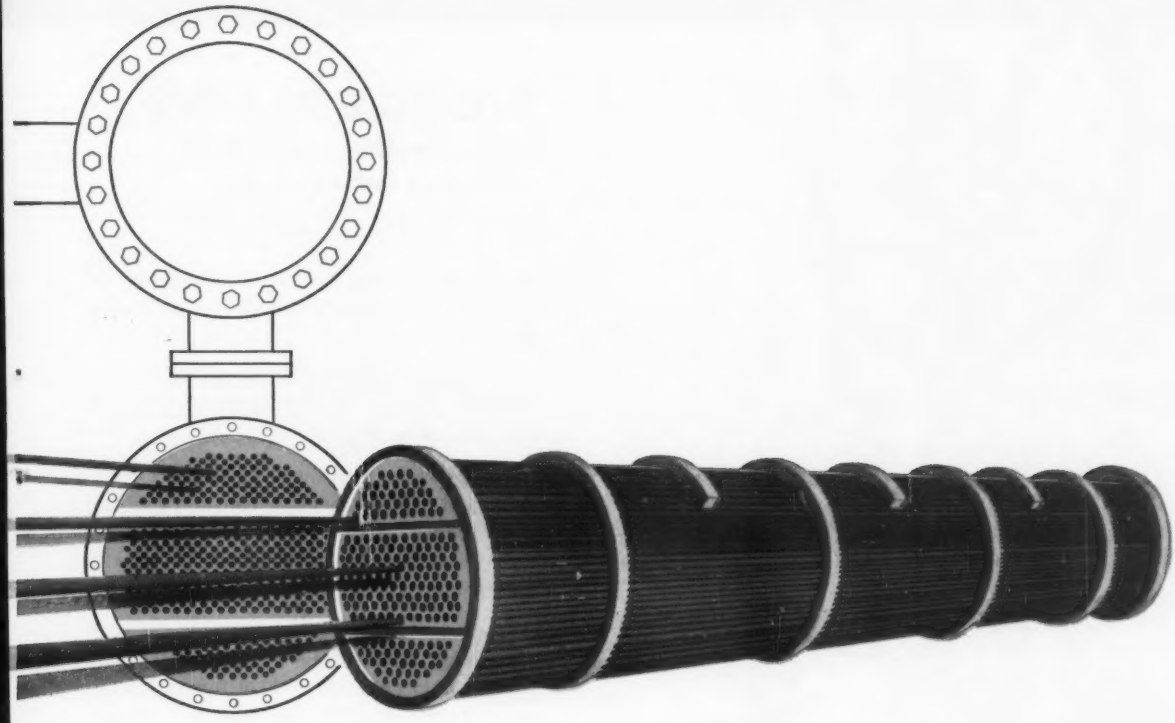

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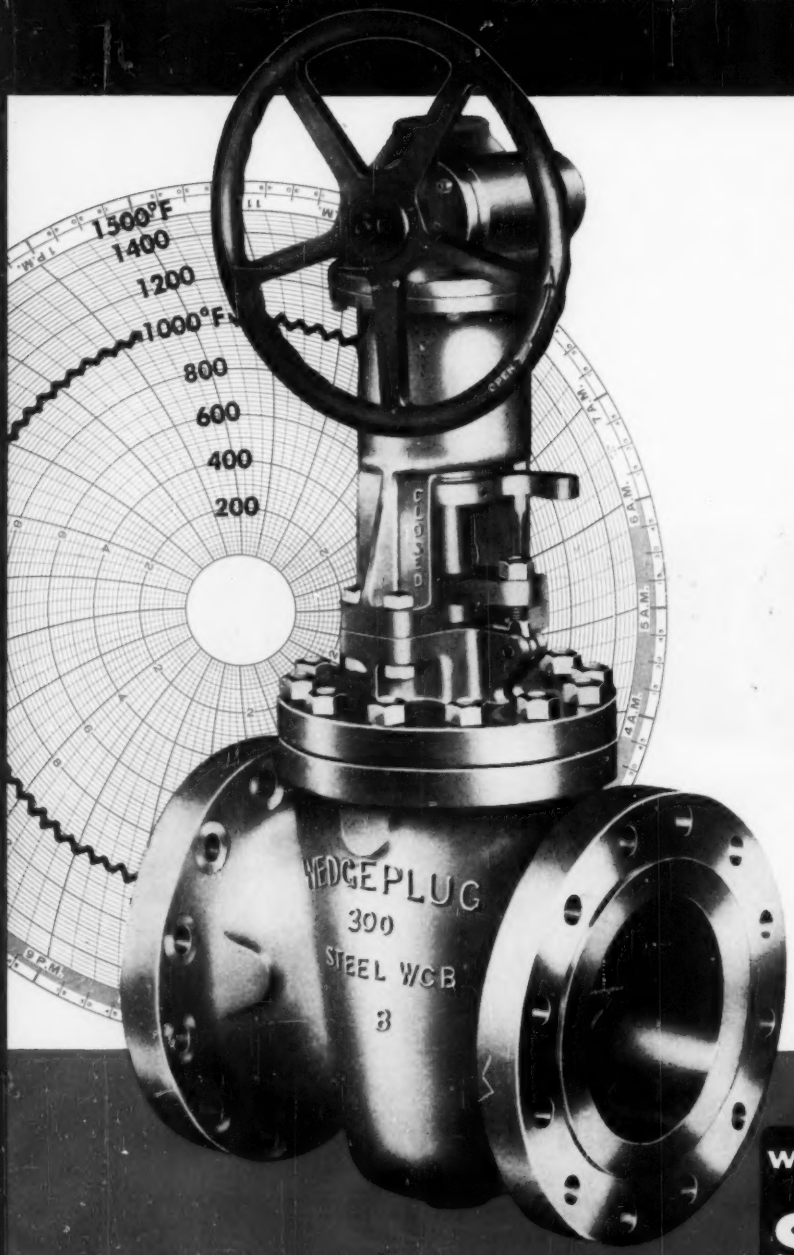

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INDUSTRY IQ QUIZ

Test your industrial IQ with this quiz on the current issue of PETROLEUM REFINER

1. Because of greater flexibility gained from the rapid recovery of unforseen events (such as an unscheduled shutdown) daily maintenance scheduling is superior to weekly scheduling in most plants today. True or False?

2. By which of the following can you measure maintenance performance?

1. By applying the formula of maintenance costs as a percent of investment cost.
2. It can't be done.
3. Analyze factors affecting maintenance to establish an index.
4. Analyze maintenance procedures and apply formula to find index.

3. Which of the following is considered optimum safety in a maintenance department?

1. Less than one injury per million manhours.
2. Less than one lost-time injury per million manhours.
3. Prevention of all injuries.
4. Less than one injury per three million manhours.

4. One way to rate the relative growth of a process is to compare its installed capacity with the total crude-running capacity of refineries. Last year, completion of new alkylation units in the United States fell so drastically that this process is no longer growing as fast as crude capacity. True or False?

5. Sandblasting storage tanks in service is a fire hazard because of the sparks created by the blasting operation, and the static electricity formed. True or False?

6. The welding machine rheostat can be used to vary voltage and thereby vary the temperature while stress-relieving a field weld with electric-resistance elements. True or False?

7. Using airless spraying to apply vinyl coatings will do which of the following:

1. Save 35 percent over other methods.
2. Cost 35 percent more than other methods.
3. Save 42 percent over other methods.
4. Cost 42 percent more than other methods.
5. Cost about the same as other methods.

8. Can the same digital computer be used for both plain and finned tubes in heat exchanger design?

9. Production of synthetic ammonia in 1959 was 8.8 billion pounds. What percentage of existing capacity was used: 75 percent, 80 percent or 87 percent?

10. If most of your cooling problems include fluids above 150° F, evaporative cooling will probably be your best bet. True or False?

11. A Swedish study has revealed five key shortcomings of company presidents. Which three of the following were in this list:

1. Over-exertion.
2. Increased work outside the firm, creating a "vacuum" in top management.
3. Too much contact with important groups outside the firm.
4. Too much time spent reading non-business literature.
5. Sidestepping the lines of authority.

12. One of Kyowa Hakko Kogyo Co.'s four theories on why its Ube ammonia plant exploded was that foreign articles accumulated at the bottom of No. 1 counter-current tower, inducing the blast. True or False?

Answers on Page 272

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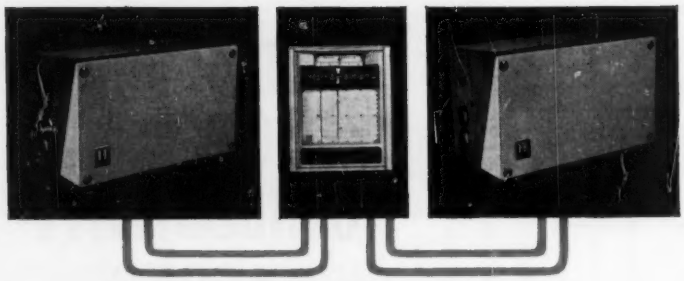

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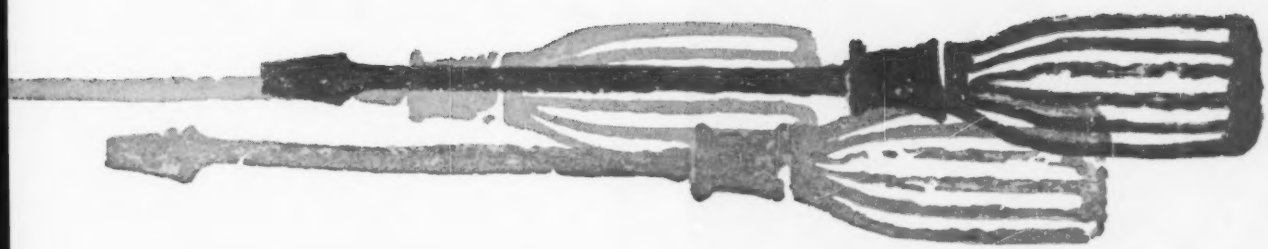

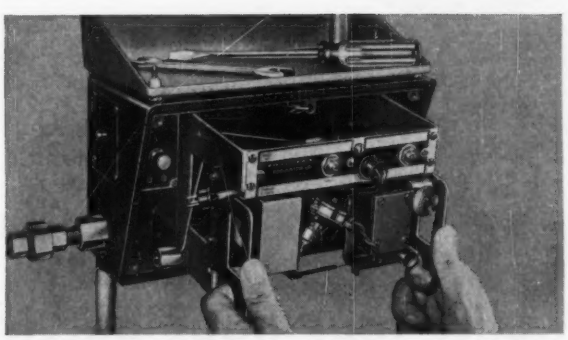

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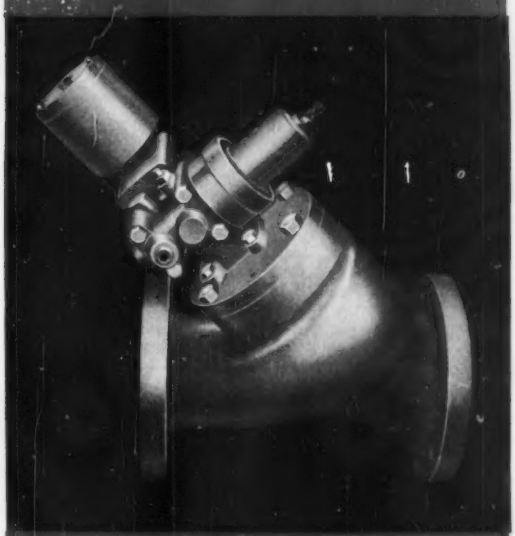

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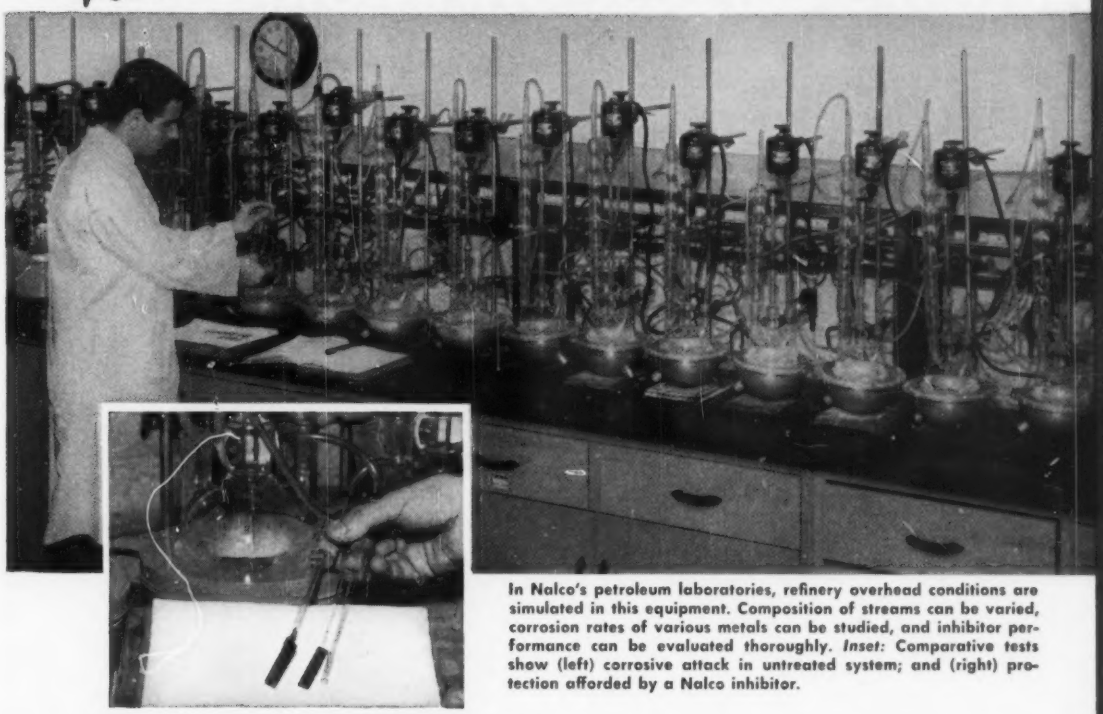
Keasbey & Mattison at Ambler

Nalco® CORROSION CONTROL PROGRAMS



In Nalco's petroleum laboratories, refinery overhead conditions are simulated in this equipment. Composition of streams can be varied, corrosion rates of various metals can be studied, and inhibitor performance can be evaluated thoroughly. *Inset:* Comparative tests show (left) corrosive attack in untreated system; and (right) protection afforded by a Nalco inhibitor.

COMBINE:

EFFECTIVE INHIBITORS

COMPLETE TECHNICAL KNOW-HOW

FAST, EFFICIENT SERVICE

Nalco inhibitors give you maximum protection at minimum cost . . . help you get many extra years of service out of every piece of equipment. They allow you to maintain maximum protection despite variations in feedstocks and wide pH fluctuations. Throughout your entire system the rapid film-forming action and high temperature stability of Nalco inhibitors will help you gain and keep the finest corrosion control.

Research on petroleum industry corrosion problems is a continuous study project at Nalco. This broad program of basic research into theories of corrosion inhibition and practical application studies makes Nalco's inhibitors highly effective and extremely versatile. The technical excellence of Nalco service is the result of extensive field experience and continuous laboratory research on corrosion control. Improve your operating picture and reduce maintenance costs with proven inhibitors and better methods of corrosion control.

There are Nalco Representatives in every petroleum processing area of the country, and near most major refining centers of the world—ready to respond immediately when you need assistance. Let them help you determine the extent of your corrosion problems, recommend inhibitors, advise on application techniques, set up chemical control programs, and help evaluate results. Call your Nalco Representative for action, or write for detailed data in free File G-3.

for BEST CORROSION CONTROL RESULTS

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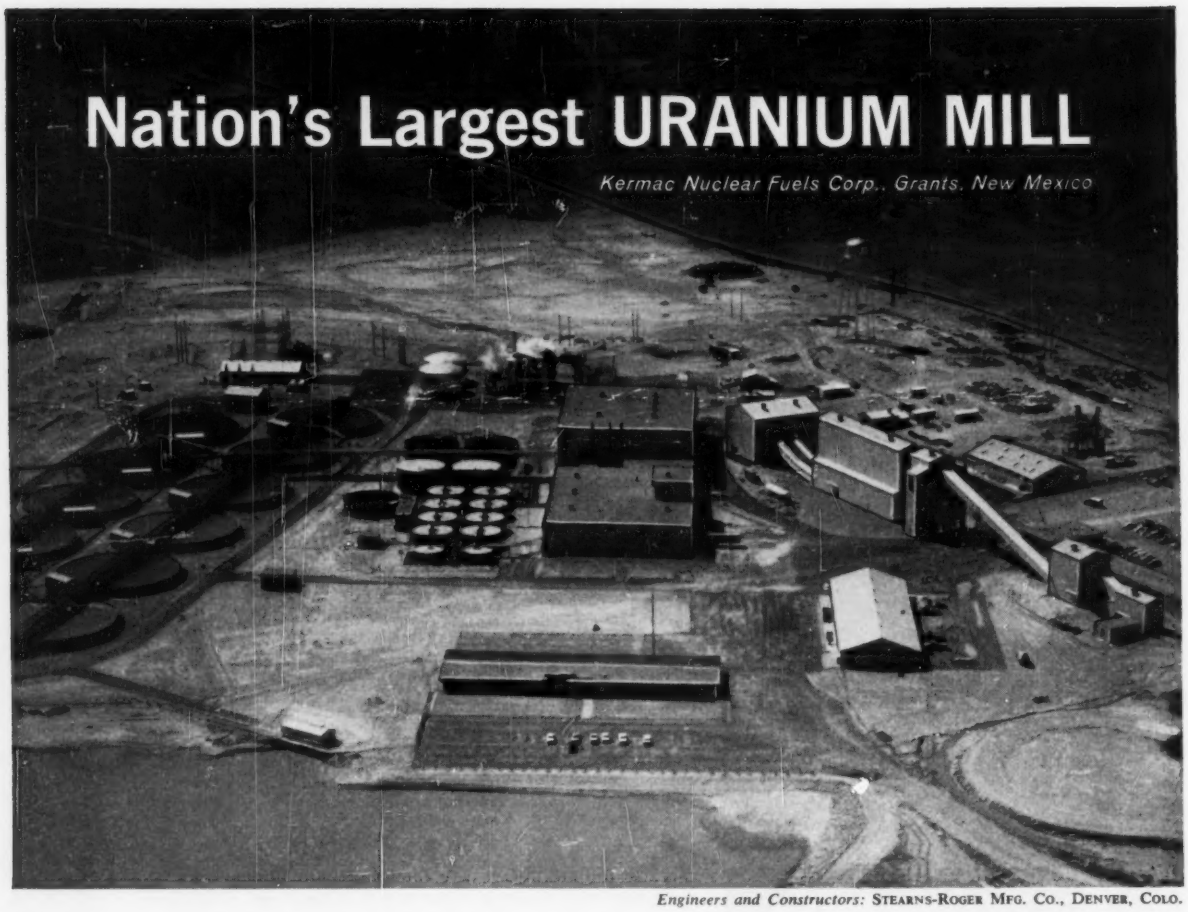


Engineers and Constructors: STEARNS-ROGER MFG. CO., DENVER, COLO.

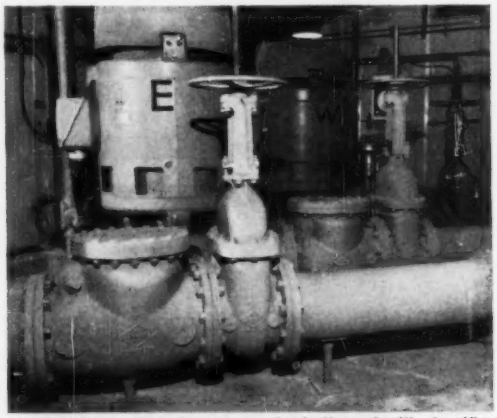
Here, uninterrupted functioning of valves is vital to continuous operation ... so JENKINS VALVES were chosen

This $18,000,000 mill, built in 1958, produces uranium oxide, called yellowcake, from raw uranium ore. Four to five pounds of yellowcake are obtained from a ton of ore by an acid leach, solvent extraction process perfected by Kerr-McGee Oil Industries, Inc. The product is sold under contract to the Atomic Energy Commission.

In the processing, ore and its many derivative components are put through so many washing operations that the mill might be termed the world's biggest "laundry". The valves controlling the use of plant process water are in continuous service.

The chance of valve trouble must be minimized here. It was accomplished by installing JENKINS valves ... chosen on their record of dependable, long-life performance in critical services for almost a century.

YOU PAY NO MORE when you demand these famous valves for your jobs. And, you gain substantial savings through reduced maintenance and replacement of valves. Jenkins Bros. 100 Park Avenue, New York 17.



Jenkins Valves control process water to the rod mill, classifier sections and the acid plant. Also, lines in power house and heating system.

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VALVES
JENKINS
SINCE 1864
Jenkins Bros

Sold Through Leading Distributors Everywhere

PRODUCT IMPROVEMENT WITH

PETRECO

EFFICIENT DESALTING is the first step toward PROFITABLE REFINING

Salt removal is now a routine operation in all modern refineries. With the need for effective desalting widely recognized, the main problem today is the selection of that equipment which will do the most efficient job at the least possible cost.

When you need new or additional desalting facilities, keep these points in mind:

■ ***The first electric desalter was designed and installed by Petreco engineers.***

This was nearly a quarter of a century ago. The subsequent years of solid, practical experience in dealing with (and solving) desalting problems all over the world now enable Petreco desalting to yield salt removals in the 98-100% range. The fraction of a cent per barrel desalting cost is saved many times over by the gains in refining efficiency resulting from a clean charging crude.

■ ***The first chemical desalter was designed and developed by Tretolite engineers.***

Tretolite chemical formulations were the first ever to be used in desalting. Tretolite desalting units are the only exclusively chemical desalters ever to be sold and installed in the refining industry and are currently used to desalt a million and a half barrels per day. In fact, every important development in crude oil desalting has resulted from the Petrolite research, engineering and development program.

YOU GET

98-100% SALT REMOVAL

WITH PETRECO ELECTRIC OR

TRETOLITE CHEMICAL DESALTING

Because Petreco offers both kinds of desalters, the company has no "axe to grind". This means that you get an honest and objective appraisal of the method best suited to your operation.

There is no other desalting equipment on the market today that can offer you comparable efficiency of design. The operating records from installations around the world *prove* it! There's no other company, either, that can offer you Petreco's fund of desalting technology or Petreco's rich background in this highly specialized field.

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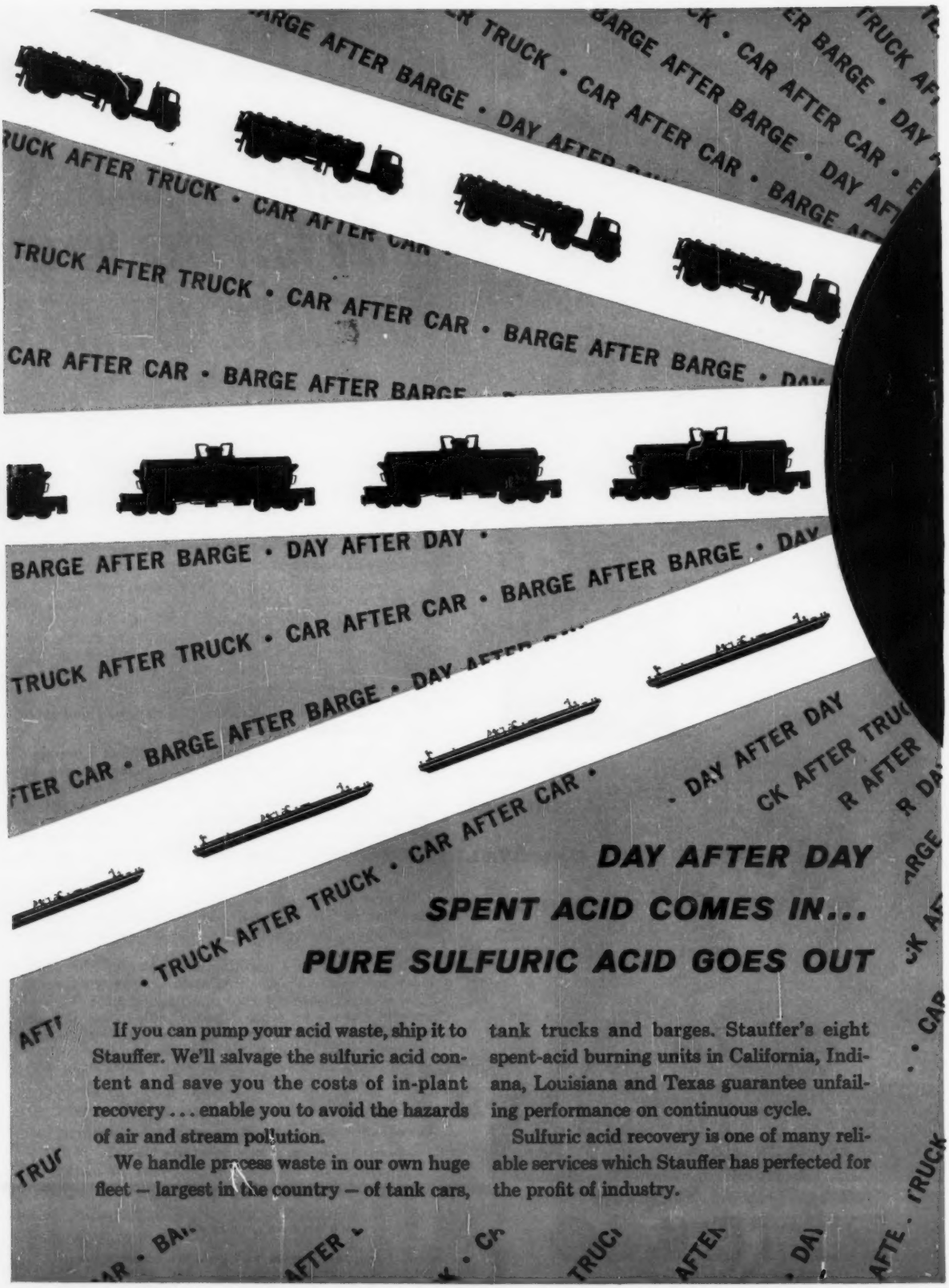
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SPENT ACID COMES IN...
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If you can pump your acid waste, ship it to Stauffer. We'll salvage the sulfuric acid content and save you the costs of in-plant recovery . . . enable you to avoid the hazards of air and stream pollution.
We handle process waste in our own huge fleet — largest in the country — of tank cars, tank trucks and barges. Stauffer's eight spent-acid burning units in California, Indiana, Louisiana and Texas guarantee unfailing performance on continuous cycle.
Sulfuric acid recovery is one of many reliable services which Stauffer has perfected for the profit of industry.
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ANY QUESTIONS ABOUT SPENT ACID REGENERATION?

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- ☐ "Stauffer Chemicals . . . Everywhere": New publication with illustrations and non-technical description of the broad line of Stauffer Chemicals.
- ☐ Annual Report, 1959, Stauffer Chemical Company

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In its forty years of service to the Northwest, American has become recognized as one of the principal sources of supply for the fabrication and field erection of steel plate products. Highly skilled workmen, an outstanding engineering staff and a variety of shop and field testing methods guarantee precision and quality.

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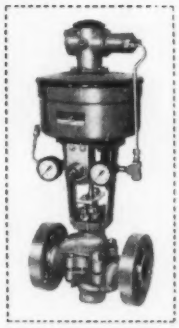
THANK YOU, COMPETITION!



Thank you control valve manufacturers. We see by your ads in the trade press and your exhibits at shows, that you are now offering split-body valves with cylinder actuators.

As most of you know, we have been manufacturing and marketing our Series LB split-body, cylinder-actuated valve for ten years. When we first started making the Series LB control valve—a radical departure from the then conventional double-seated valve with spring and diaphragm actuator—we did it because we sincerely believed it was the best way to control process fluids.

Those of us who pioneered the split-body, cylinder-actuated valve invested considerable time, money and effort in extolling its many features. As the years went by and user acceptance increased, we became stronger in our belief. However, there were many times during those years when we would have welcomed confirmation from you in the form of competitive products. Now, your announced entry into this field is, to us, a gratifying endorsement of the concept we have spent so much of our energies in developing. The added impetus that your collective advertising and sales efforts will give to publicize the benefits of the split-body, cylinder-actuated valve will contribute materially to its universal acceptance.

Although we know we have a good product backed by a decade of design and manufacturing experience, we do not intend to rest on our laurels. We will continue to offer industry the very best control valve we can make. And you will strive to outdo us. Your customers—and ours—and our industry—can only benefit from this healthy competition. Again, we thank you for following this lead in control valve technology.

CONOFLOW SUBSIDIARY WALWORTH

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

2100 ARCH STREET, PHILADELPHIA 3, PA.

For more data on advertised products, use Readers' Service Cards, last page.

New Series of Marsh Needle Valves in 316 STAINLESS STEEL

—Valves that take you out of your corrosion problems

Now still wider service range for the valves that have set new standards in the needle throttling field. A full line of Marsh Needle Valves are immediately available in 316 stainless steel in the new series 1936.

Identified by **blue handles**

Here is a valve that opens up the wide range of corrosion-resistant applications bracketed by 316 stainless. It is a valve that gives precision throttling at pressures from a few pounds through 6000 psi . . . a valve for any temperature from minus 100° F. to plus 500° F. thanks to the "Marpak" packing system making use of precision moulded Teflon.

Only Marsh experience—in both valve making and instrument making—could have produced these valves. Like other Marsh needle valves, they are available in globe and angle patterns and in panel mounted types; sizes, ⅛", ¼", ⅜", ½", ¾" and 1". The 316 stainless valves are fully described in Bulletin NV-3.

Marsh Needle Valves are also available in 416 stainless steel (identified by green handles) and in mild steel (identified by yellow handles.)

The Marsh touch—
the precision touch—in every detail

- Body and stem guide machined from 316 stainless bar stock.
- Accurately machined stem, precision ground and rolled.
- Longer inlet and outlet thread chambers insure tight make-up.
- Packing as corrosion-resistant as the valve.

MARSH *Needle Valves*

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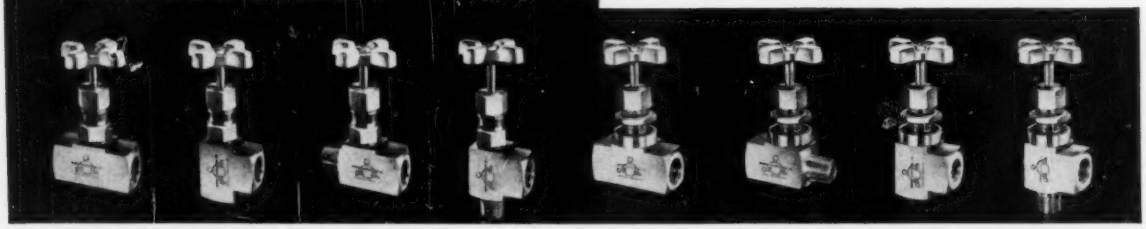
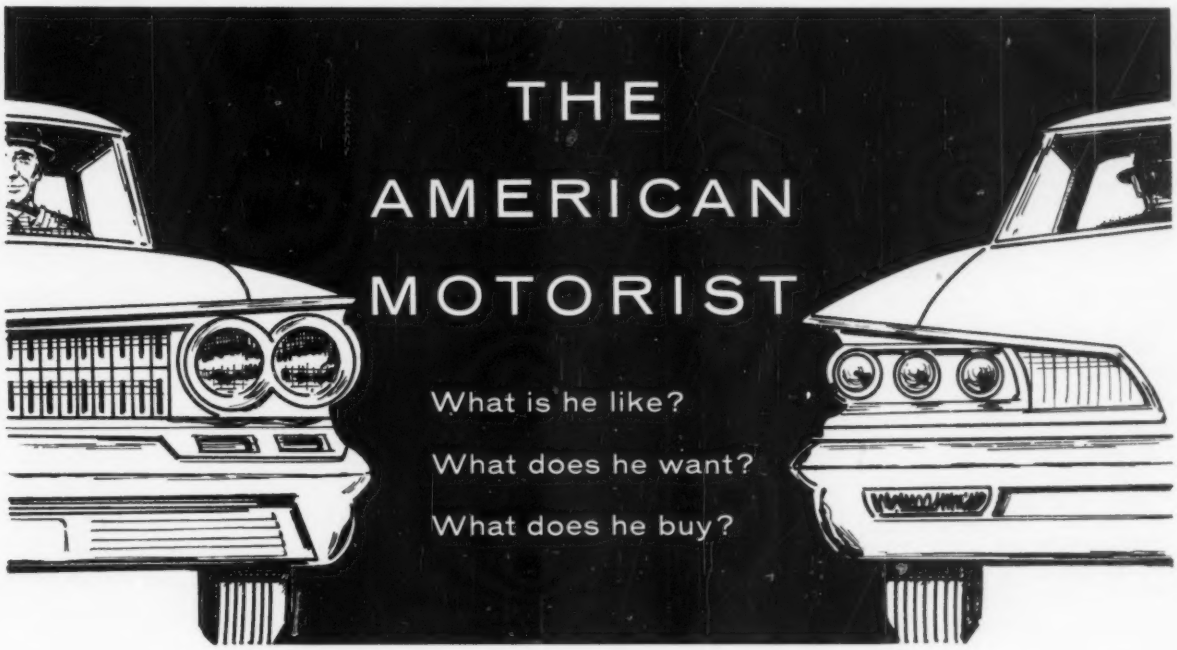


DU PONT *Petroleum Chemicals* NEWS

Number 106 in a series of bulletins for the Petroleum Industry

JANUARY • FEBRUARY 1961



New Du Pont study of 4,507 motorists reveals latest trends in buying habits

Are motorists becoming more loyal to their local service stations . . . or less?

How much influence do give-aways have in the motorist's choice of gasolines?

What percentage of people use their cars on vacations? How popular are credit cards? How do they influence buying habits?

These are just a handful of the questions answered by Du Pont's newest survey, "Profile of the Motorist"– the fourth in a series that constitutes the most complete study ever made of the American motoring public.

From coast to coast, 4,507 motorists were interviewed in this survey. Each interview was a penetrating study of the person's likes and dislikes, and his or her buying habits. Some 61 questions were asked, ranging from "Did you buy at a station with lower prices during a price war?" and "Do you still usually buy your gasoline at this station?" to "Do you have access to a private swimming pool?" and "Where did you spend your last vacation?"

The result of this interviewing is a vast array of data which has been fed into a processing system from which various combinations of facts can be extracted to answer specific questions for oil marketers.

Your questions answered

The "Profile of the Motorist" survey is part four of Du Pont's continuing investigations (begun in 1952) into the patterns of motorists' buying habits. These studies are offered to the industry as a service from Du Pont.

For further information, contact your Du Pont Petroleum Chemicals representative.

Man with the facts

at Du Pont is Roberts W. Brokaw, survey analyst in the Special Services Section, who is in charge of assembling data from the "Profile of the Motorist" study to answer specific questions for Du Pont customers. Mr. Brokaw has been with the Petroleum Chemicals Division since its formation in 1947 and has supervised all previous motorist studies.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

The show about the road is now on the road

Every road in America leads to adventure.

This, in seven words, is the theme behind one of the oil industry's newest travel development tools – Du Pont's new half-hour color movie, "Highway Holiday."

"Highway Holiday" is a 16mm version of the CinemaScope feature "Down the Road," which is now being distributed to theaters across the nation by 20th Century-Fox. "Holiday" is designed for non-paying showings to any interested group. Both films are part of Du Pont's marketing services to the oil industry.

"Highway Holiday" takes the audience to all corners of the American continent – from the sweeping highway across the Painted Desert to a historic old village in New England, from the gleaming sands of Daytona to the majestic mountains of Canada, from Quebec to Mexico.

All this travel has a meaning. "Highway Holiday" will encourage a greater appreciation of the heritage and beauties of America, and stimulate motorists' interest in seeing them firsthand

through the convenience and comfort of the family car.

Prints available

You can obtain prints of "Highway Holiday" for showing to clubs and other groups, or for local television use. The film is intended to provide you, as a marketer of gasoline and other oil products, with a *broad* "expand-the-demand" promotion, as a backdrop for your own travel development activities.

For further information, contact your Du Pont Petroleum Chemicals representative.

ASSISTANT GENERAL MANAGER

CARL S. OLDACH is Assistant General Manager of Du Pont's Organic Chemicals Department, one of the divisions of which is Petroleum Chemicals.

Mr. Oldach joined the company in 1940, as a senior chemical engineer in the Ammonia Department (now the Polychemicals Department) laboratories at the Experimental Station in Wilmington. In succeeding years he held several technical management positions in the department, and in 1955 he became Assistant Director of the Development Department. In 1958 he was transferred to the Organic Chemicals Department as Director of Sales of the Freon® Products Division. In May 1960, he was appointed to his present post as Assistant General Manager of the department.

Mr. Oldach has a Doctor of Science degree in chemical engineering from the Massachusetts Institute of Technology, in addition to his Bachelor of Science degree from Yale University.

He has published a number of scientific articles relating to analysis of sulfur compounds in gases. He is a member of the General Committee of the Refining Division of the API, and also holds memberships in the American Institute of Chemical Engineers and the American Chemical Society.

Born November 28, 1914 in San Diego, Calif., Mr. Oldach now lives in Wilmington, Del. with his wife, two daughters and son.

Low-cost way to break foam in gas scrubbing

Here is a new wrinkle that is already helping several companies to cut the cost of foam breaking in atmospheric and vacuum distillation processes.

The foam-killer that makes this possible is Du Pont's OCENOL,® which is already well known for its anti-foam advantages in amine processes for removing H_2S and CO_2 from liquid hydrocarbons, natural and refinery gases.

OCENOL carries a low price tag, and works effectively in small concentrations of only 0.1 to 0.3 lb. per 1,000 barrels. The result is that you pay a very low price to break foam with OCENOL.

Facts in data sheet

OCENOL is a technical grade of oleyl alcohol, rich in cetyl and unsaturated C_{16} alcohols. It is available in two forms: OCENOL and OCENOL P. OCENOL P contains a lower proportion of unsaturates than OCENOL. In some applications, the products can be used interchangeably.

For information, contact your Du Pont Petroleum Chemicals representative.

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OVER

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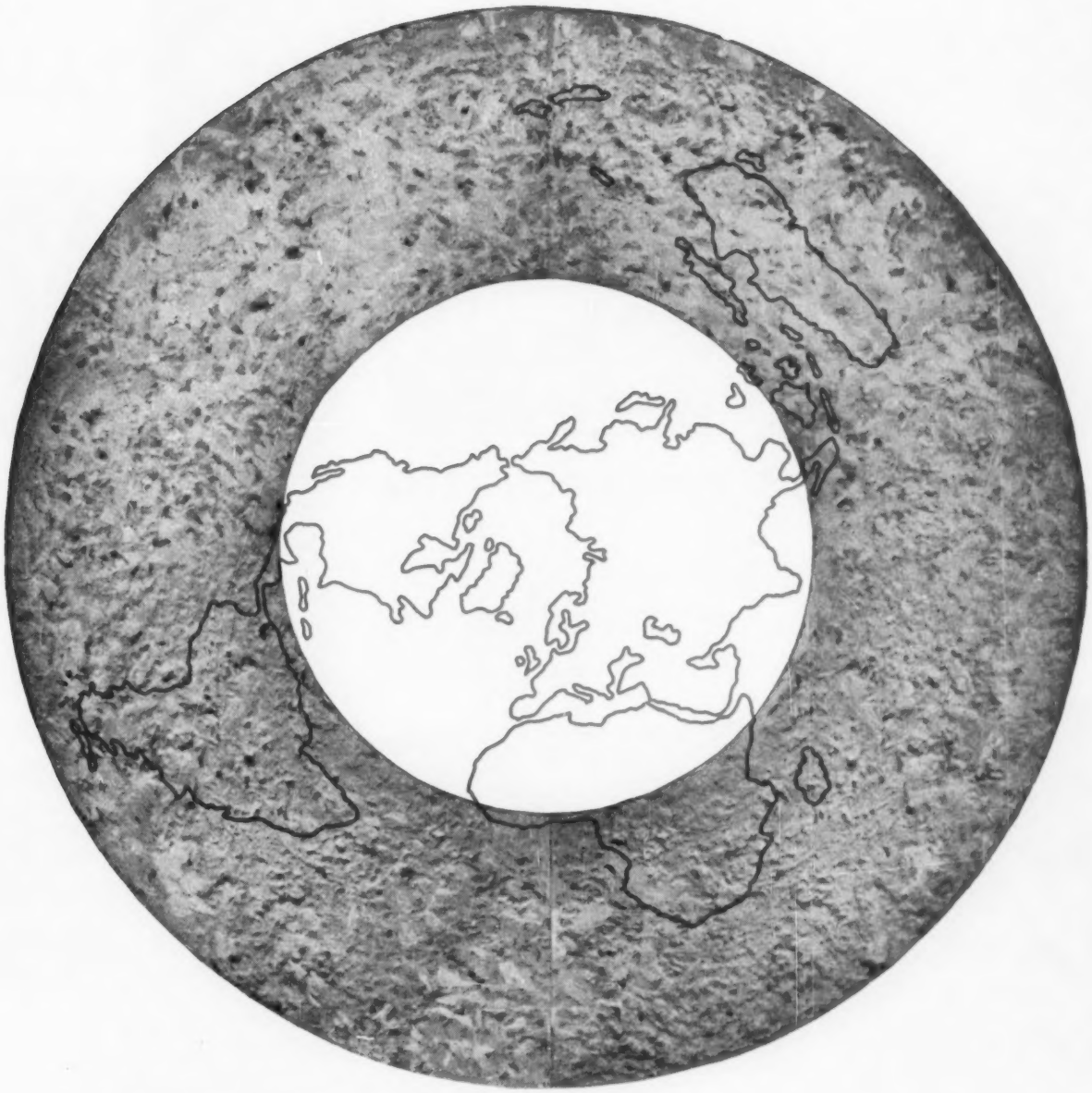

made the world over

—and to the same specification

Caposite amosite asbestos is manufactured under supervision to the same uniform specification in all these countries.

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Canada	by Caposite Insulations Ltd
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Australia	by James Hardie & Company Ltd
France (as 'Isolamiante')	by Isolamiante SA
Italy	by Capamianto SpA
Holland	by J. de Boer & Company
Spain	by Messrs. Eduardo Rosa
Argentina	by Montisol Argentina, SRL
Japan	by Nippon Asbestos Company

Amosite asbestos insulation is also manufactured in U.S.A. under the name of 'Unibestos' by Union Asbestos Rubber Company.

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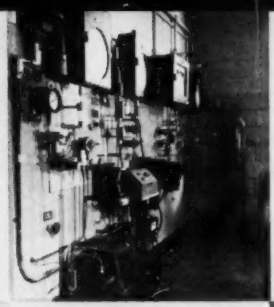

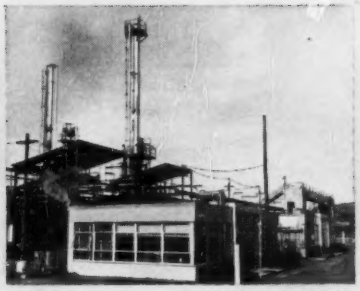

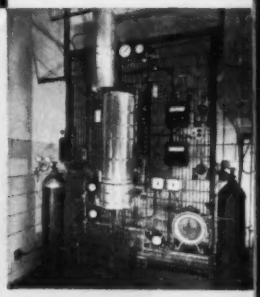

DIVERSE CUSTOM PROCESSING

TRULAND provides diverse custom processing facilities. Included are high temperature, atmospheric and vacuum stills (continuous as well as batch type), autoclave reaction facilities, a Rodney Hunt "TURBA-FILM" Processor, stainless steel reactors and, our most recent addition, a column employing molecular sieves for separating and purifying.

Use Truland's facilities and experience to upgrade and dispose of organic wastes and by-products economically. Our technical personnel will be pleased to review your processing and product needs and discuss with you a way in which we may help. Please inspect our facilities and meet with our personnel.

TRULAND

TRULAND CHEMICAL COMPANY

East Rutherford, New Jersey

Division of THE TRUBEK LABORATORIES

A Modern Concept of Maintenance

MAINTENANCE BY CONTRACT

reverses the current trend toward higher maintenance costs this way . . .

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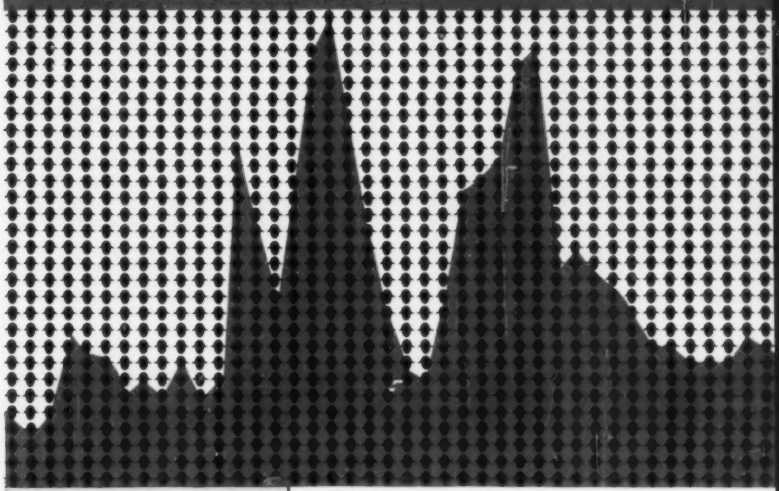

2. Detailed planning, scheduling and cost control

3. Multi Plant experience

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Ethyl Corporation of Canada, Ltd.
The Goodyear Tire & Rubber Company
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Sun Oil Company, Ltd.
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Dow Chemical of Canada, Ltd.
Firestone Tire and Rubber Company
Hercules Powder Company
Phillips Chemical Company
St. Lawrence Cement Company
Stauffer Chemical Company
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HELPFUL WATER CONDITIONING DATA FROM BETZ

HOW TO TREAT ONCE-THROUGH

Here is a review of the water treatment problems encountered in once-through cooling water systems—and the means available for their correction.

THE TERM "COOLING WATER" is applied wherever water is circulated through equipment to absorb and carry away heat. Cooling water systems can be classified as closed, open recirculating or once-through. The once-through system, as the name implies, is one in which the water is passed through the heat exchange equipment to absorb heat and then is discharged directly to waste or is used for some other purpose. The usual source of once-through cooling water is from wells, rivers and lakes where the cost involved is that of pumping only.

In a once-through cooling system no evaporation takes place and consequently the water does not concentrate. Therefore, the water characteristics remain substantially unchanged.

Generally, the once-through cooling system is favored because of its simplicity, lower capital investment, and lower operating costs when compared to the more complex open recirculating system. This is true where water of a suitably low temperature is readily available in large volume and at a low cost—*providing the quality of the water is also satisfactory*. Too often, scale formation, iron deposits, slime accumulation and corrosion lead to inefficient operation and require frequent cleaning, high maintenance costs and equipment replacement when water of poor quality is used. As a result, operating costs far exceed those anticipated and the "simplicity" of the once-through cooling system can disappear.

Scale Formation

Calcium carbonate is usually the chief ingredient of scale formed in once-through cooling systems. It is possible to predict from the water characteristics whether a water will produce calcium carbonate deposits for the operating conditions imposed. The physical factors that primarily influence scale formation are temperature, heat transfer and velocity. The chemical factors are calcium, alkalinity, pH and dissolved solids. By calculating the saturation index and the stability index of the water it is possible to predict with a high degree of accuracy whether calcium carbonate deposits will form and produce operating difficulties.

The most common method employed to inhibit calcium carbonate scale formation in once-through cooling systems is the use of various anti-nucleating agents that possess the property of preventing crystal growth and thereby prevent scale formation. The materials most commonly employed for this purpose include the polyphosphates, tannins, lignins and polyacrylates. Specific blends of these materials make it possible to secure the added benefits of each in preventing scale formation. Treatment levels generally range between 3 and 30 ppm depending on the degree of over-saturation with respect to calcium carbonate and the severity of the operating conditions imposed.

Figure 1—Typical iron deposition in pipe line.

Iron Deposits

A special case of scale formation may be encountered in once-through cooling water systems that employ well waters containing iron. The iron content of well waters varies widely and has been noted to range between 0.3 and 30 ppm. The iron found in well waters usually exists as ferrous bicarbonate which is unstable and will undergo decomposition to form ferrous oxide at points of heat transfer.

In addition to heat, oxygen and other oxidizing agents (such as chlorine) will hasten the decomposition of ferrous bicarbonate. Iron bearing well waters commonly contain iron bacteria which utilize iron in their life cycle. Well waters containing high amounts of iron and iron bacteria will produce rapid plugging of pipelines as illustrated by Figure 1.

Efficient treatments are available that will complex the iron and prevent precipitation. While the polyphosphates are capable of complexing iron, organic complexing agents such as citrates[1] and lignosulphonates[2] are considerably more effective. Blends of these materials have been used successfully in treating industrial cooling waters containing as high as 30 ppm of iron.

When iron bacteria are present it usually is necessary to control iron bacteria by a supplementary treatment. Generally, chlorination is not used because it hastens precipitation of the iron and detracts from the efficiency of the iron retention treatments. Special organic toxicants have been developed which effectively control iron bacteria and are compatible with the iron retention treatments.

Slime Formation

Biological fouling of heat exchangers is encountered frequently in once-through cooling systems that utilize polluted surface supplies. Less frequently, well waters are encountered that contain a high bacteria count that will produce slime formation. Slime formation will seriously interfere with heat transfer and in addition will accelerate corrosion. In most instances chlorination on a continuous or intermittent basis will serve to control slime effectively. As pointed out previously, however, chlorine rarely is the best recommendation when ferrous bicarbonate is a problem.

Corrosion

Corrosion in once-through cooling systems probably is the most costly of the difficulties encountered. Replacement of expensive equipment, pipelines and the loss of production are the end result. In once-through cooling systems, the principal factors influencing corrosion are

(1) Covered by U.S. Patent 2,529,177.
(2) Covered by U.S. Patent 2,744,866.
(3) Dianodic is a Betz trade name. The methods are covered by U.S. Patents 2,711,391; 2,900,222; 2,872,281; 2,848,299.

the water characteristics, temperature, velocity, and contact of dissimilar metals. The chief variables controlling the corrosion characteristics of the water are its dissolved oxygen content and carbon dioxide concentration. Occasionally, other factors are involved such as the presence of free mineral acid or hydrogen sulfide.

Particularly where *surface supplies* are used such as rivers, streams and lakes, the major cause for corrosion is dissolved oxygen. Figure 2, shows the effect of oxygen concentrations on the corrosion of low carbon steel at different temperatures. Philadelphia tap water was used in these tests, with a pH of 6.7 and a flow rate of 2.5 feet per second. Elimination of dissolved oxygen will effectively control corrosion. Vacuum deaeration has been successfully applied to once-through cooling systems for oxygen removal, but this method entails a considerable investment cost as well as

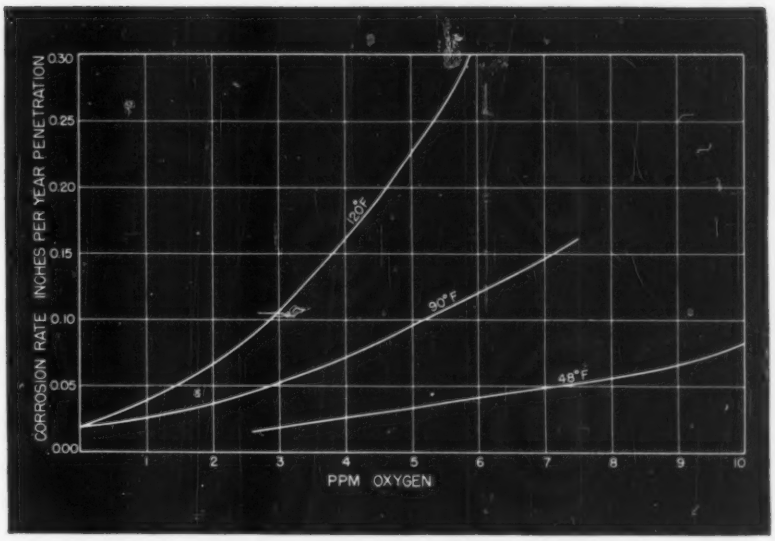

Figure 2—Effect of oxygen concentration at different temperatures.

COOLING SYSTEMS

a continued operating cost. Chemical deaeration also has been applied successfully and involves reacting the dissolved oxygen with catalyzed sodium sulfite. Chemical treatment costs with this method are approximately $1.00 per million pounds of water per part of dissolved oxygen. While waters low in dissolved oxygen can be economically treated, when the dissolved oxygen content exceeds approximately 3 ppm other chemical treatment methods usually will prove more economical.

Waters that contain appreciable amounts of oxygen can be treated more economically by inhibitors that form films or barriers which stifle the corrosion reactions. The Zinc-Dianodic methods,[3] which utilize combinations of polyphosphate, chromate and zinc inhibitors are particularly effective since they function by stifling both the anodic and cathodic corrosion reactions. The Zinc-Dianodic treatments are capable of rapidly forming a continuous, impervious film that will effectively passivate the metal surfaces and stifle the corrosion reaction. The rate at which the initial film forms is dependent upon treatment concentrations. Accordingly, the principles of pretreatment should be followed to establish the protective film rapidly. Once the film is formed, normal treatment levels, on the order of 10 to 20 ppm, will effectively maintain the film and prevent corrosion.

Well waters generally are devoid of dissolved oxygen and when carbon dioxide concentrations are low and hydrogen sulfide is absent, the corrosion rate will be negligible. However, frequently well waters do contain high concentrations of carbon dioxide on the order of 25 ppm or greater. Even in the absence of dissolved oxygen, excessive corrosion will take place not only of ferrous metals . . . but also of copper and its alloys. In these instances neutralization of the carbon dioxide either partially or totally will be required to prevent corrosion. When this corrective method is followed it is essential that the saturation and stability indices of the water be recalculated since the water may be rendered scale forming with respect to calcium carbonate and a supplemental treatment with an anti-nucleating agent may be necessary.

The most difficult of corrosion problems occurs when hydrogen sulfide is encountered. Hydrogen sulfide may be present in a water supply due to purely chemical or purely biological causes. The presence of hydrogen sulfide is more common in well waters than surface waters. Wells located in Boulder clay areas or "sour gas" fields frequently contain hydrogen sulfide. The presence of sulfate reducing bacteria may also be responsible for producing hydrogen sulfide. Generally, heavy chlorination of the water is required to consume the hydrogen sulfide. However, the proper treatment method will be contingent upon whether ferrous bicarbonate is also present, as frequently is the case.

It is essential when considering the use of a once-through cooling system that the quality of the water be investigated thoroughly from the standpoint of its potential for scale formation, iron deposits, slime accumulations and corrosion. The treatment methods for control of these problems have been well established by Betz. If you are investigating the use of a new water supply or are having problems with an existing water supply, why not call in a Betz engineer for a helpful discussion?

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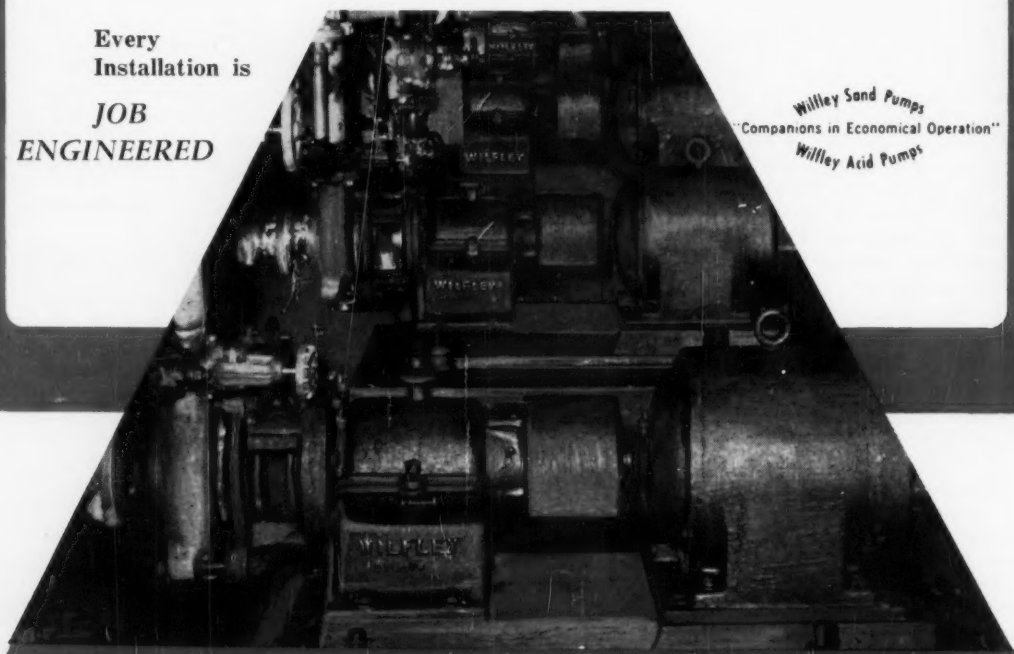

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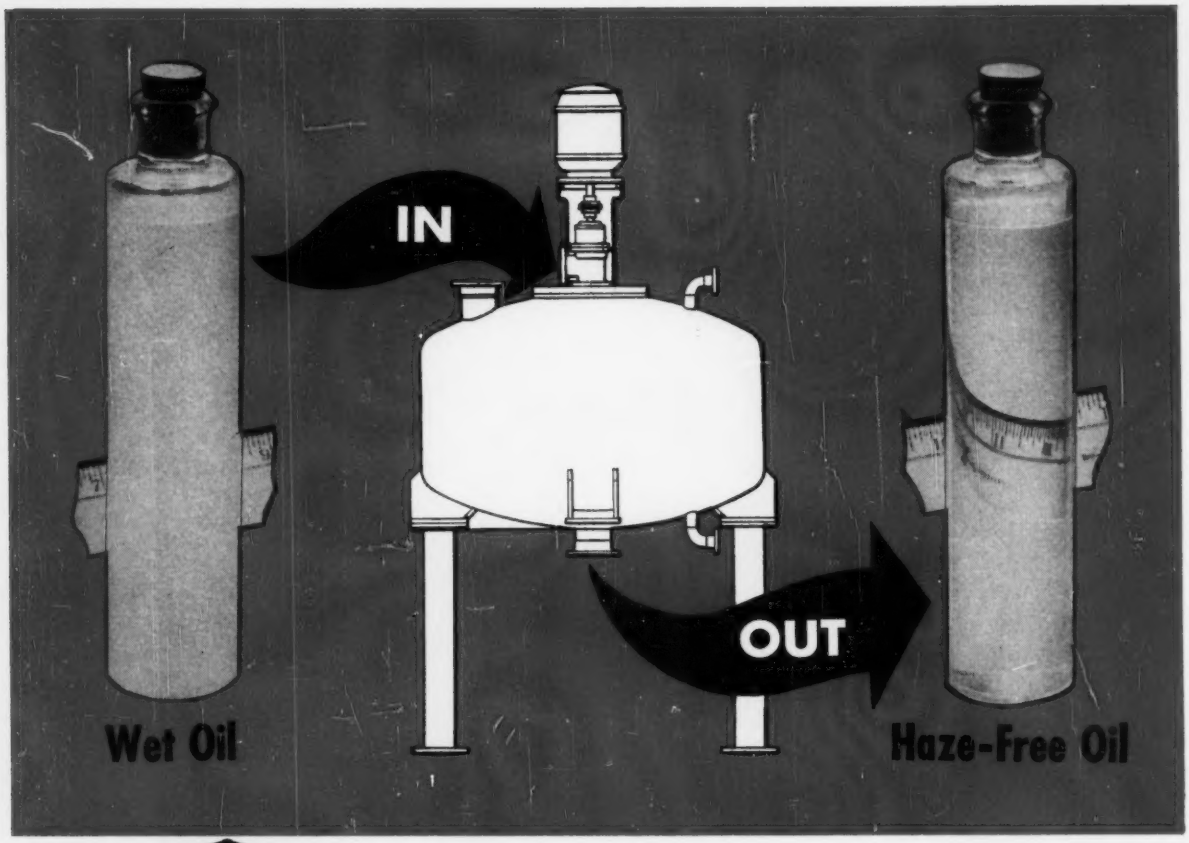

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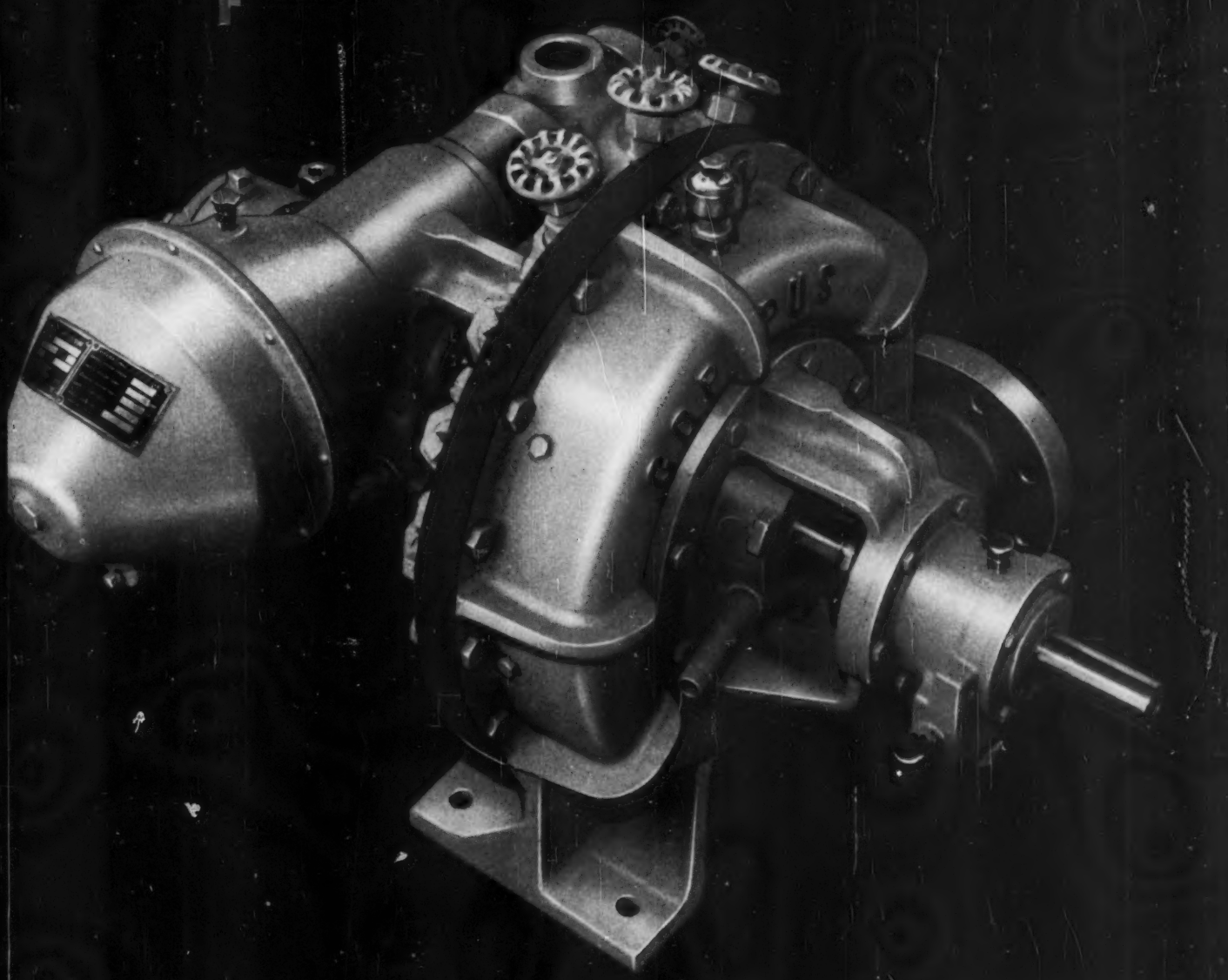

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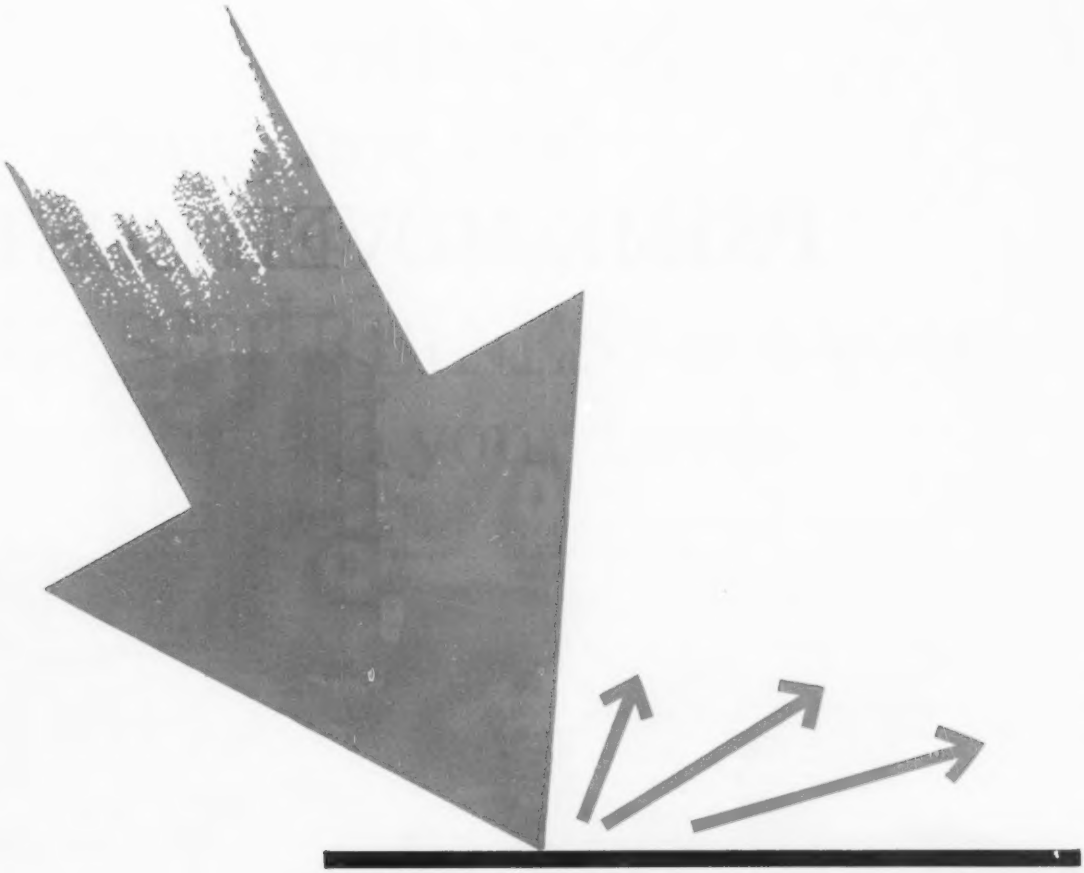

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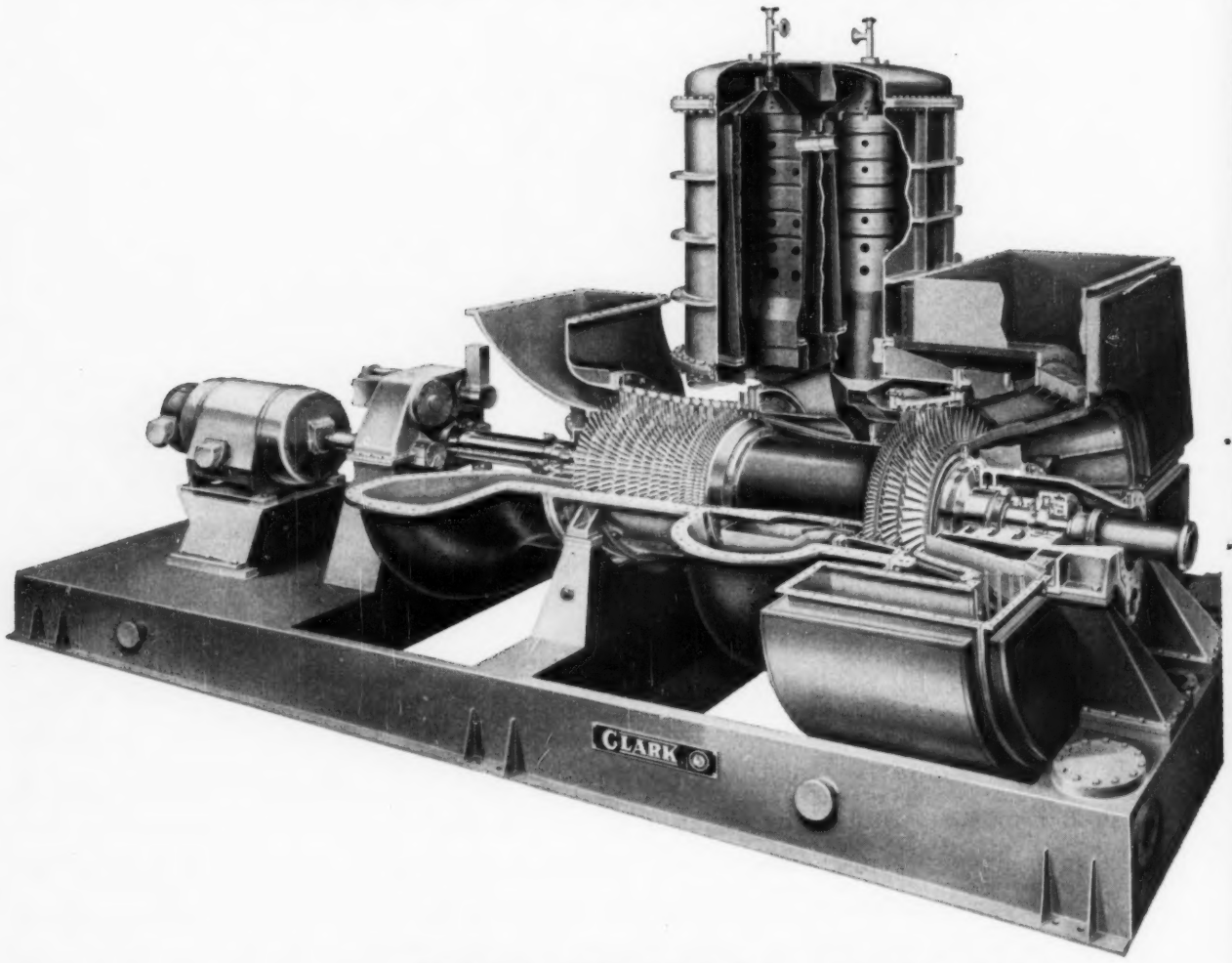

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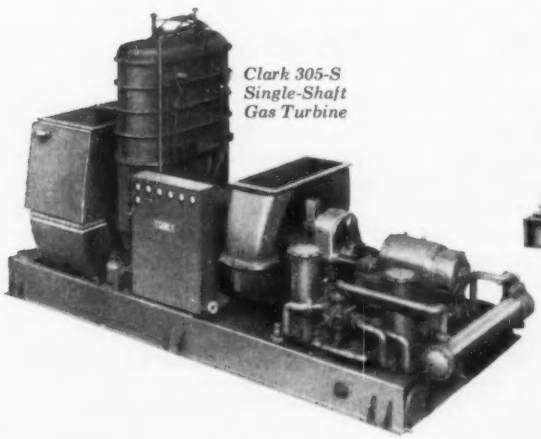
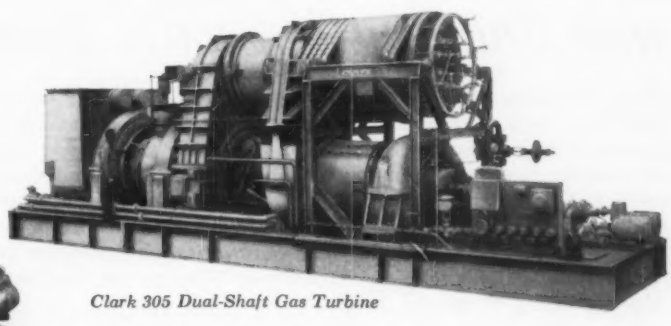


Clark 305-S Single-Shaft Gas Turbine



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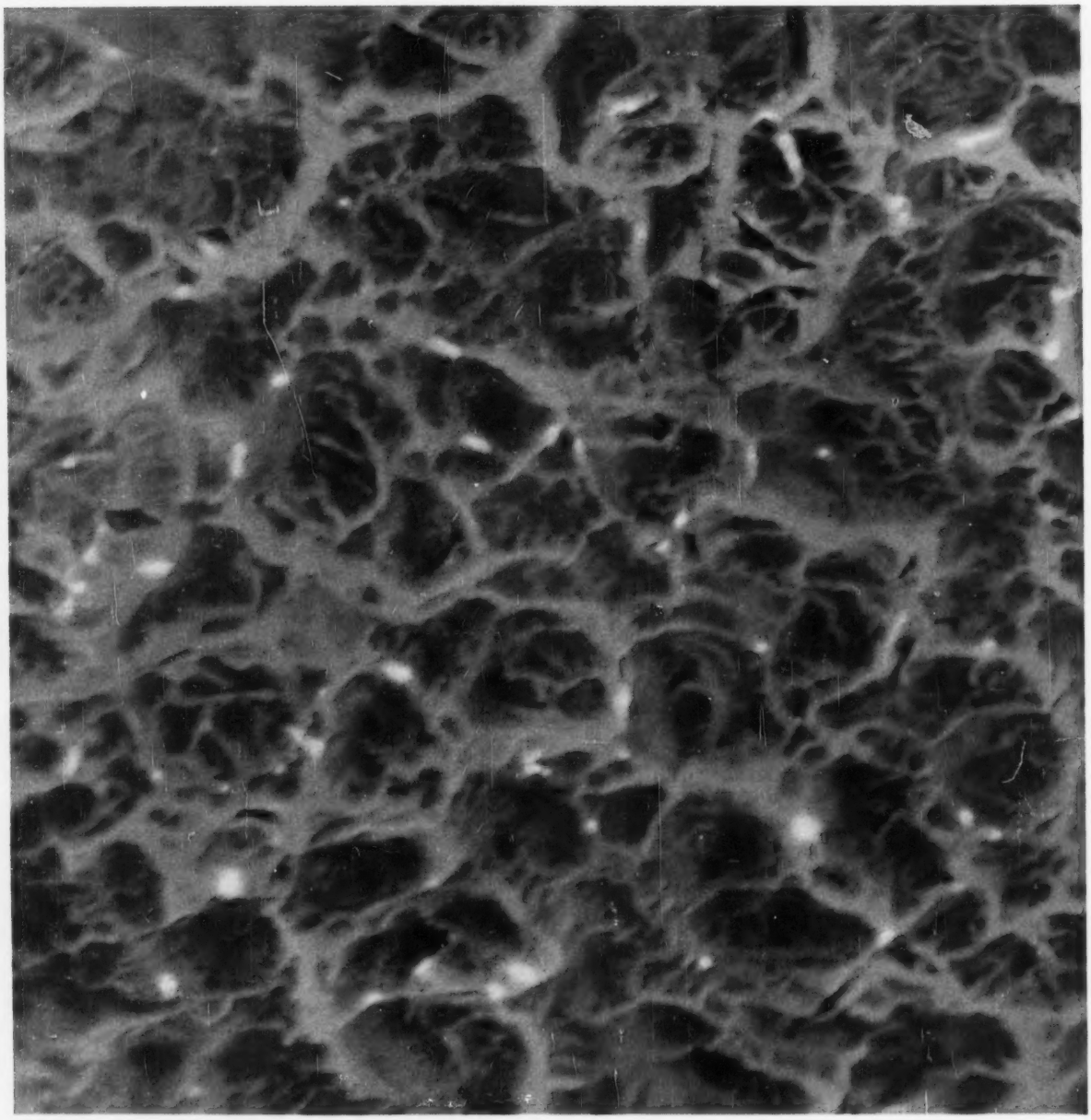

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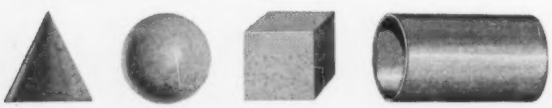

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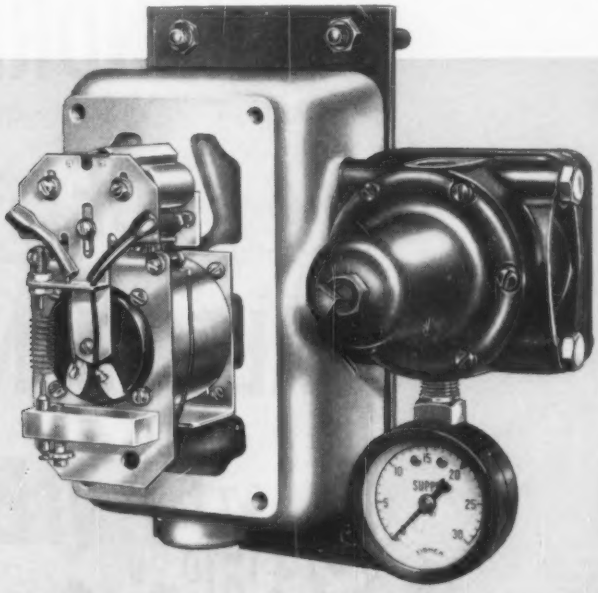

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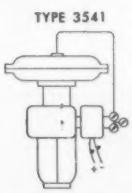

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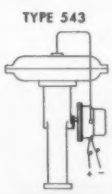

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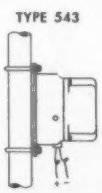

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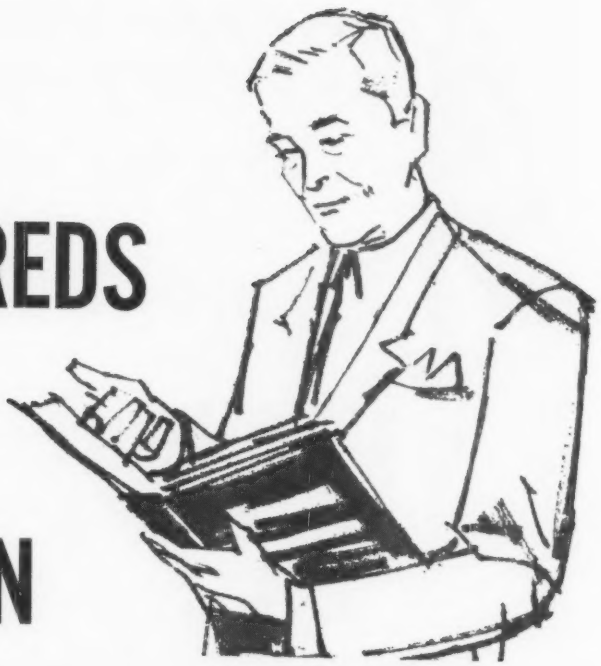

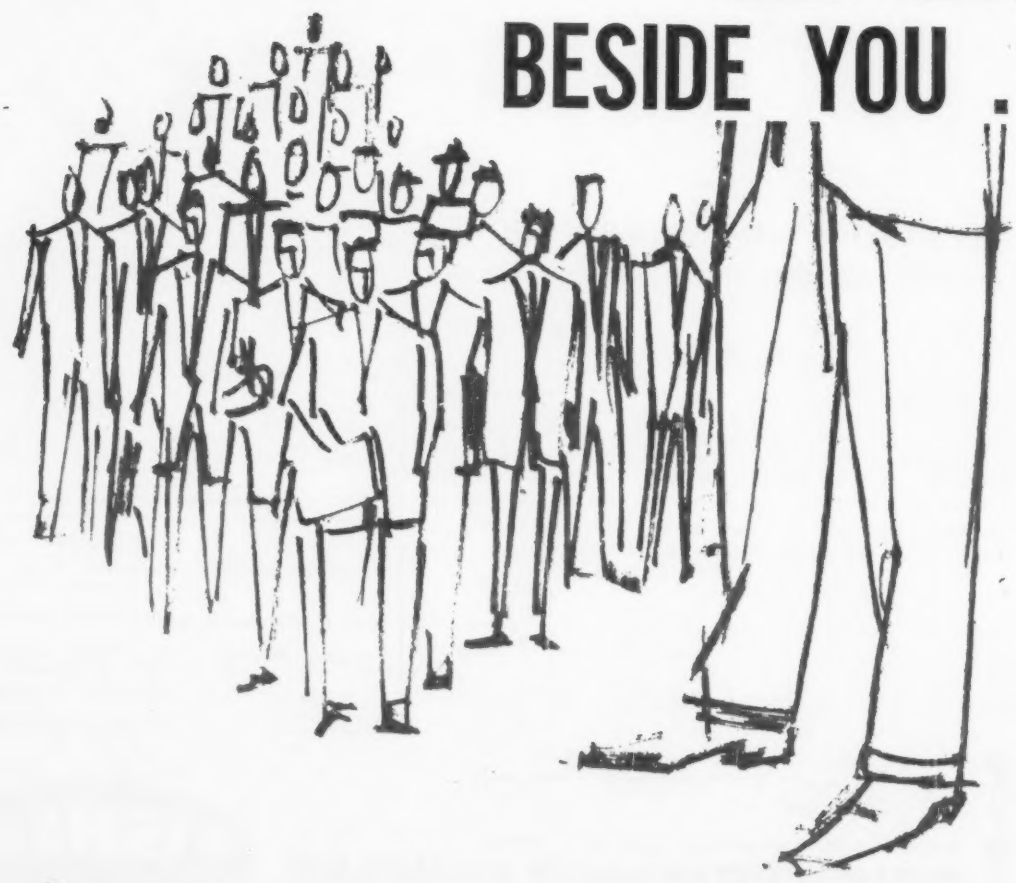

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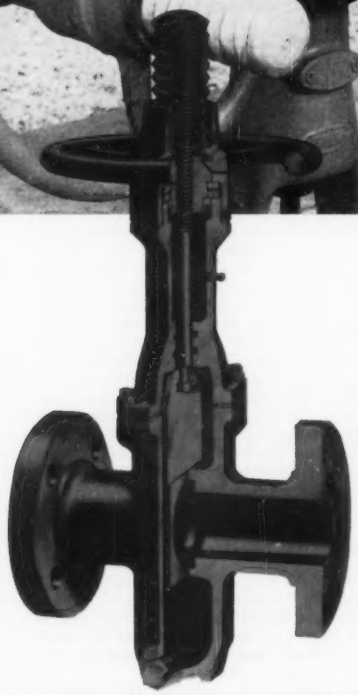
4" W-K-M Pressure Sealing Gate Valves serve as emergency shut-off for regulator handling hot P.B.C. at 440 psi, in natural gasoline plant.



Floating Seats Make Sealing Easy

Seats are specially formulated elastomer molded to a hardened steel insert. When the gate closes, line pressure forces the gate against the downstream seat making a tight seal. The upstream seat floats against the gate to maintain an upstream seal.

Emergency shut-off is a cinch with W-K-M's Pressure Sealing Gate Valve

A unique W-K-M seat design makes line pressure do most of the work — sealing the seats to positive shut-off, upstream and down. But easy operation is only part of the story.

W-K-M's new Pressure Sealing Gate Valve is ruggedly dependable. It automatically compensates for seat wear, automatically relieves excessive body pressure. And on-the-line overhaul is a simple matter.

Wherever you need a smooth-operating valve for pressures to 720 psi and temperatures to 250° F., specify W-K-M's new Pressure Sealing Gate Valve. Sizes 2" through 30" — at leading distributors.

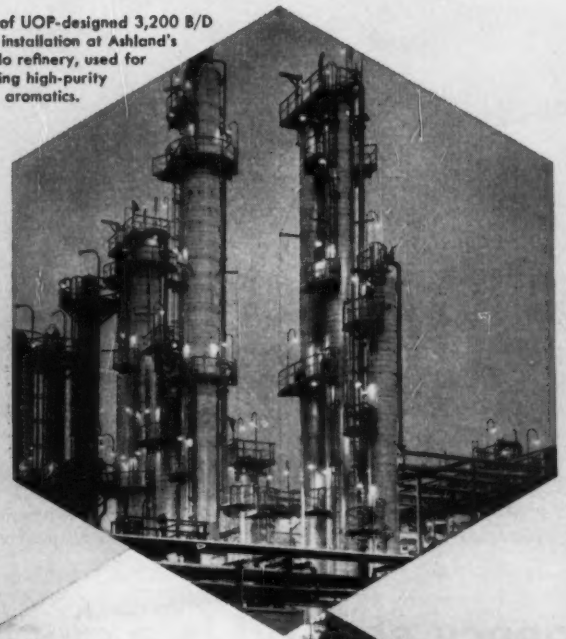
WRITE FOR CATALOG 1200

W-K-M

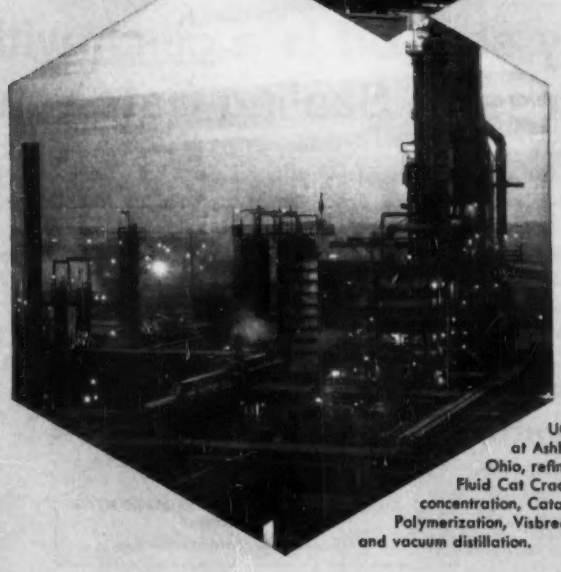
DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

6009

Udex® installation plays major role in Ashland's petrochemicals expansion program



View of UOP-designed 3,200 B/D Udex installation at Ashland's Buffalo refinery, used for producing high-purity aromatics.



UOP-designed units at Ashland's Canton, Ohio, refinery include Fluid Cat Cracking, gas concentration, Catalytic Polymerization, Visbreaking and vacuum distillation.

UOP processes contribute to Ashland's remarkable 36-year growth

By Robert E. Yancey,
Administrative Vice President
Ashland Oil & Refining Company
Ashland, Kentucky

R. E. Yancey

From a small 1,000 B/D skimming plant consisting of four shell stills in 1924, Ashland has grown to an operation utilizing six refineries with a total daily throughput in excess of 150,000 barrels of crude oil and an annual sales volume of $300,000,000.

Ashland serves the Ohio Valley and Great Lakes area through an efficient transportation network of crude oil lines, refined product lines, river towboats and barges, lake tankers, and trucks . . . Ashland branded products are sold through 3,500 service station outlets, and unbranded products through more than 1,000 independent distributors.

Udex, Hydeal*, and Naphthas Fractionating units provide expanded production of petrochemicals, jet and missile fuels

Our latest important expansion has taken place in the area of petrochemicals and other specialty products, such as aliphatic and aromatic solvents, special jet and missile fuels. Under this program a 3,200 B/D Udex unit for production of high-purity aromatics was placed on stream in May, 1958, at our Buffalo (N. Y.) refinery. Another UOP unit, now under construction at our Catlettsburg (Ky.) refinery will be the first commercial Hydeal process unit in operation for the production of benzene and naphthalene. Developed jointly by Ashland and Universal, this hydrodealkylation process will be used to produce benzene and naphthalene from low value heavy aromatics and alkylnaphthalenes. Benzene and naphthalene from the Udex and Hydeal units have numerous markets in the area of synthetic fibers, synthetic rubber, plastics, paints and other related fields.

Sales of petrochemicals and specialty products jump 44% in one year

Ashland's big push into the field of petrochemicals and specialty products proved extremely successful in 1959. Sales in these two areas jumped 44% in dollar volume over the previous year.

The importance of this new field of expansion was aptly phrased by Rexford S. Blazer, chairman of the board. "These sales . . . are highly profitable and demonstrate the value of the program of manufacturing diversification which the company will continue to expand. We place great emphasis on the production of tailor-made products for specialized uses throughout the great industrial area which can be served economically from our refineries and terminals."

Early facilities included Butane Isomerization and 'HF' Alkylation

Ashland's widespread activities are directed from the company's general headquarters located at Ashland, Kentucky, in the tri-state West Virginia-Ohio-Kentucky area. Catlettsburg, near Ashland, has been the site of Ashland's main refinery since the company's birth in 1924. The present corporation was formed in 1936 with the consolidation of Swiss Oil Corporation and Ashland Refining Company.

As sales increased, new units were added at Catlettsburg, many of UOP design. These included bubble tower fractionation (1925), an early single-coil Thermal Cracking unit (1926) later converted to two-coil, one of the first Catalytic Polymerization units for converting olefinic gases into high-octane gasoline, a combination crude atmospheric and vacuum distillation unit for the manufacture of asphalt and cylinder stocks (1938), a Butane Isomerization-'HF' Alkylation plant and catalytic cracking unit constructed during World War II for the production of aviation gasoline, and a 30,000 B/D fresh feed UOP Fluid Catalytic Cracking unit with gas concentration facilities added in 1956. Additional crude processing facilities were added in 1956 to increase the crude throughput to 80,000 B/D.

Company acquisitions add more process facilities and marketing outlets

Over the years, through the additions of various companies, Ashland now manufactures and markets a great variety of petroleum specialty products, many of which are sold in foreign markets. UOP processes and engineering services have been utilized extensively and to good advantage in all of our refineries. The Canton refinery, which has a crude capacity of 35,000 B/D utilizes many UOP-designed units, including Fluid Catalytic Cracking, gas concentration, Catalytic Polymerization, a Thermal Cracking unit later converted to Visbreaking, and a new vacuum distillation unit for the manufacture of asphalt.

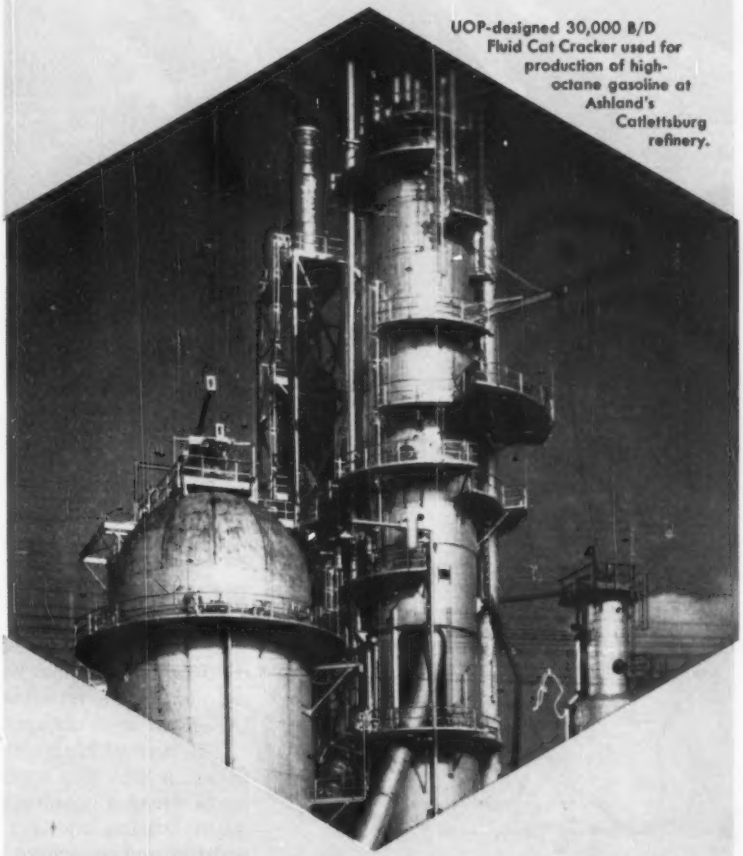
The Frontier refinery in Buffalo, N. Y., having a capacity of 32,000 B/D, is the site of Ashland's Udex installation which is an important cog in the company's petrochemical expansion program. A Hydeal unit is planned for this refinery. Additional UOP units at Frontier include Fluid Catalytic Cracking, gas concentration and polymerization. The addition of Frontier also provided Ashland with a number of valuable service station outlets and an extensive domestic fuel oil business. Asphalt is produced at Frontier as well as all of our refineries except the Valvoline plant, located at Freedom, Pa., which is primarily a lubricating oil refinery.

The purchase of R. J. Brown Company in 1956, and the Ohio-Indiana Division of Anderson-Prichard Oil Company in 1958, further strengthened Ashland's position as a refiner and marketer of industrial naphthas, solvents and petrochemicals. These two companies, along with the National Accounts Sales Department, market specialty products from our Udex and the new 8,400 B/D superfractionation units.

In November, 1959, Ashland obtained the modern refining facilities of the Louisville Refining Company, a large portion of whose processing installations were designed by UOP. Some of the more recent of these include facilities for the manufacture of asphalt, Fluid Catalytic Cracking, Unifining*, Platforming® and Merox*.

All of the six refineries now operated by Ashland have, at one time or another, installed units designed by UOP in cooperation with Ashland's engineering department. Practically all of our current expenditures are for facilities to make additional grades of profitable petroleum specialties, to upgrade the value of products from a barrel of crude oil, and to provide for more efficient and lower cost operations.

30,000 barrel-per-day Fluid Cat Cracker is a key process at Ashland's main refinery



UOP-designed 30,000 B/D Fluid Cat Cracker used for production of high-octane gasoline at Ashland's Catlettsburg refinery.

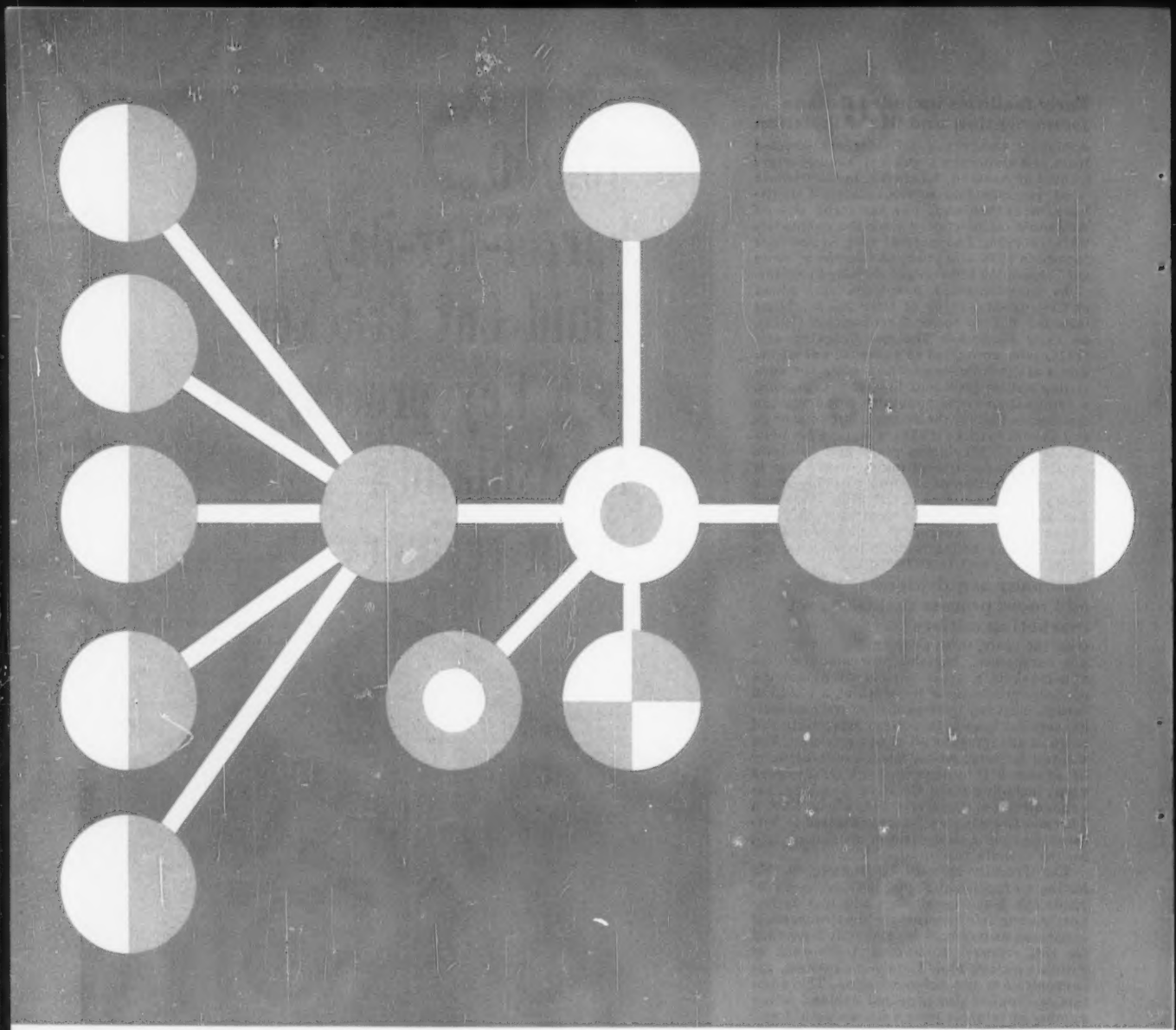
UOP®

WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U.S.A.

*Trademark



When you specify process controls...

BUYING A LOOP OR A NOOSE?

Why "strangle" process technology? Hagan solid-state, electronic controls are designed to meet rigid specifications of high reliability, simplicity, and repeatability . . . yet, they're flexible and adaptive enough to meet changing process needs.

The core of Hagan's PowrMag electronic control loop is the controller. A high gain operational magnetic amplifier within the controller produces all control actions . . . proportional band, reset, rate . . . multiplication, addition and subtraction . . . through interchangeable resistive and capacitive components.

The Hagan electronic control system expands from this controller to other components that include all the hardware necessary for a simple or sophisticated control loop. From temperature, pressure and flow measuring devices to final control elements and data acquisition, each component has been engineered to meet high standards of reliability and accuracy.

For information on Hagan PowrMag electronic process controls, write HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Pittsburgh 30, Pennsylvania, or telephone WAlnut 2-3737.

SENSING ELEMENTS

TRANSDUCERS

CONTROLLER

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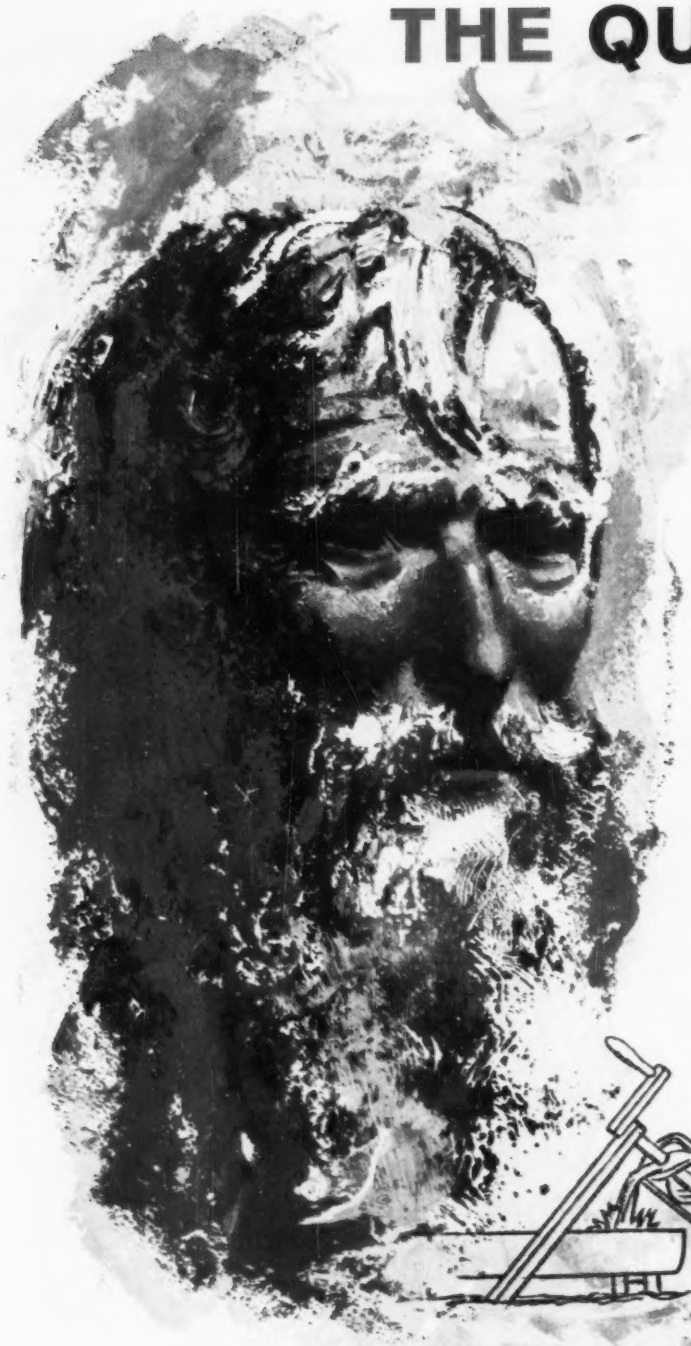
DATA PROCESSING

FINAL CONTROL

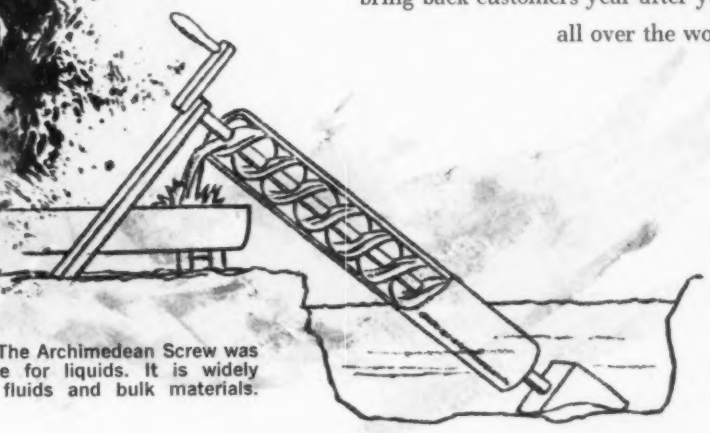
HAGAN

THE QUALITY OF THINKING



Archimedes, the ancient Greek philosopher, developed principles of mathematics and mechanics which unlocked secrets leading to the development of some of our most modern processes. His mind was at home in the farthest reaches of the abstract, at work in the closest confines of the practical.

At Brown & Root — whether it is one mind, or a group of minds — thinking knows no boundaries for inspiration. Problems in engineering and construction are solved in ways that consistently save our clients time and money. Brown & Root places a premium on the quality of thought, combined with thoroughly-seasoned knowledge and experience. The results bring back customers year after year, all over the world.



Over two thousand years ago, The Archimedean Screw was introduced as a lifting device for liquids. It is widely used today in moving both fluids and bulk materials.

BROWN & ROOT, INC.

Engineers · Constructors • POST OFFICE BOX 3, HOUSTON 1, TEXAS • CABLE ADDRESS-BROWNBILT

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For more data on advertised products, use Readers' Service Cards, last page.

HIGH PERFORMANCE STANDARDS THROUGH

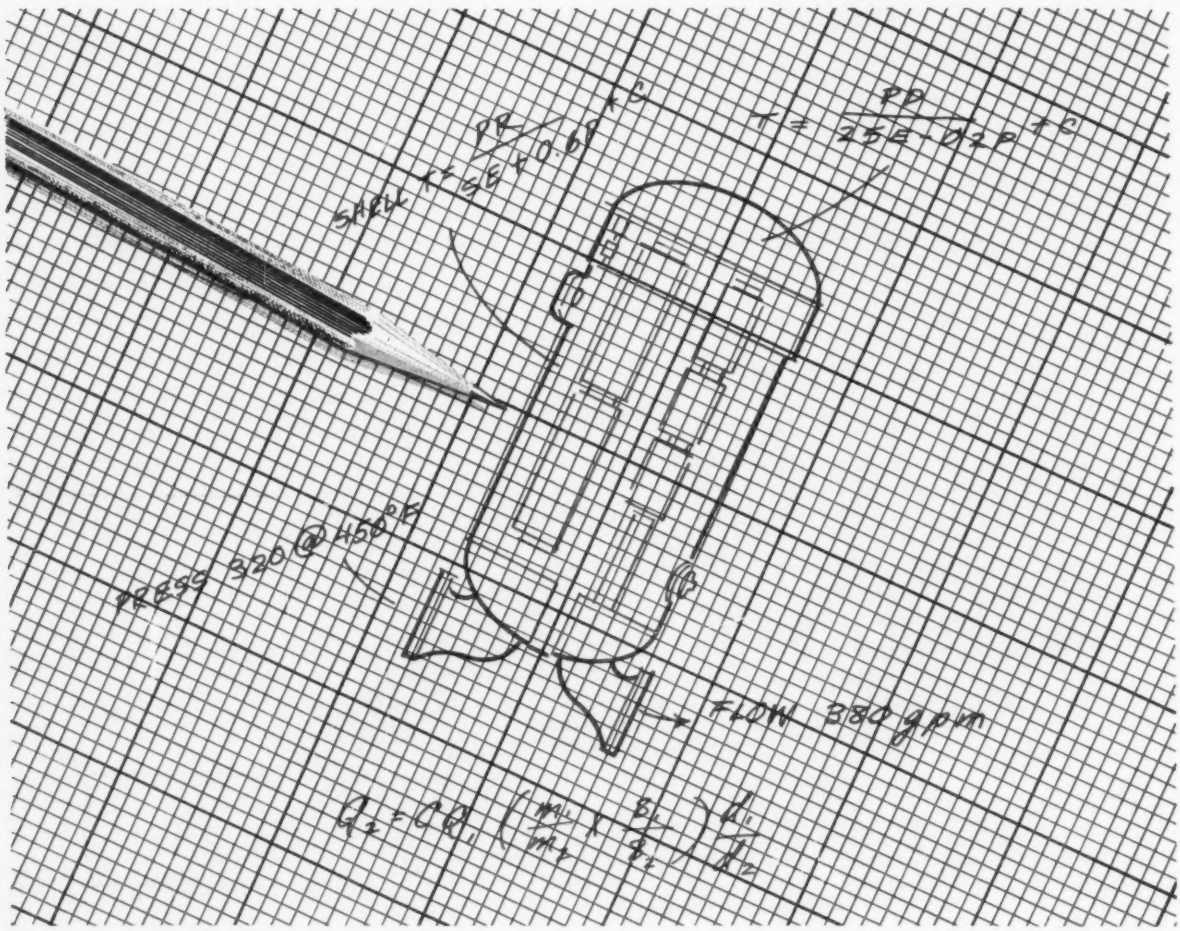
UNITIZED DESIGN

THE UNITIZED DESIGN OF WARNER LEWIS SPACE SAVER SEPARATOR/FILTERS provides the ultimate protection against water and solids contamination.

The proven superiority of Warner Lewis two-stage design is enhanced by the close correlation of over-all vessel design with details of element construction. The result: Unitized Design to achieve the highest performance standards — which are maintained only by the use of Warner Lewis factory engineered replacement cartridges.

Minimum dimension, high volume Space Saver units are designed for refuelers and hydrant carts, and for fuel farm and bulk plant installations. They are in world-wide service with the U. S. Air Force and other branches of the military services. They are installed in fueling facilities serving most of the world's major airports.

For further information, write Aviation Products Division, Warner Lewis Company.



WARNER LEWIS COMPANY
BOX 3086 • TULSA, OKLAHOMA

WARNER LEWIS COMPANY
DIVISION OF **FRAM®** CORPORATION

YARWAY news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD
STEAM TRAPS STOCKED AND SOLD BY 270 LOCAL INDUSTRIAL DISTRIBUTORS

The whole works—steam trap, strainer and blow-down valve—fit in the palm of your hand

ENTHUSIASTIC APPROVAL!

INDUSTRY WELCOMES NEW SERIES 130 IMPULSE STEAM TRAP WITH OPEN ARMS

"Radically new and different—send 50."
TEXAS INDUSTRIAL

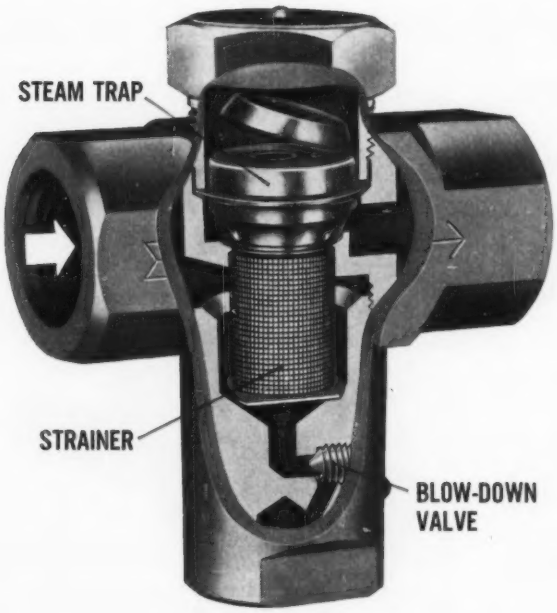
"We want 100 immediately. They meet our confined space needs perfectly."
WISCONSIN PACKER

"Ordering 60 as first part of new standardization program."
LOUISIANA REFINERY

"We'll start with 24—more later."
OHIO PETRO-CHEMICAL

So it goes—industry's welcome to the new Yarway Series 130 combination steam trap has been a warm one. Already manufacturing quotas have been doubled to meet the demand. Yarway distributors everywhere are busy answering their customers' requests for demonstrations.

What will the new Series 130 do for you? Consider these advantages:



COMPACT COMBINATION SAVES SPACE, MONEY, MAINTENANCE ON LIGHT LOAD APPLICATIONS

Steam trap, strainer, blow-down valve combination simplifies trapping hook-ups—saves up to 30% in time and materials over ordinary hook-ups.

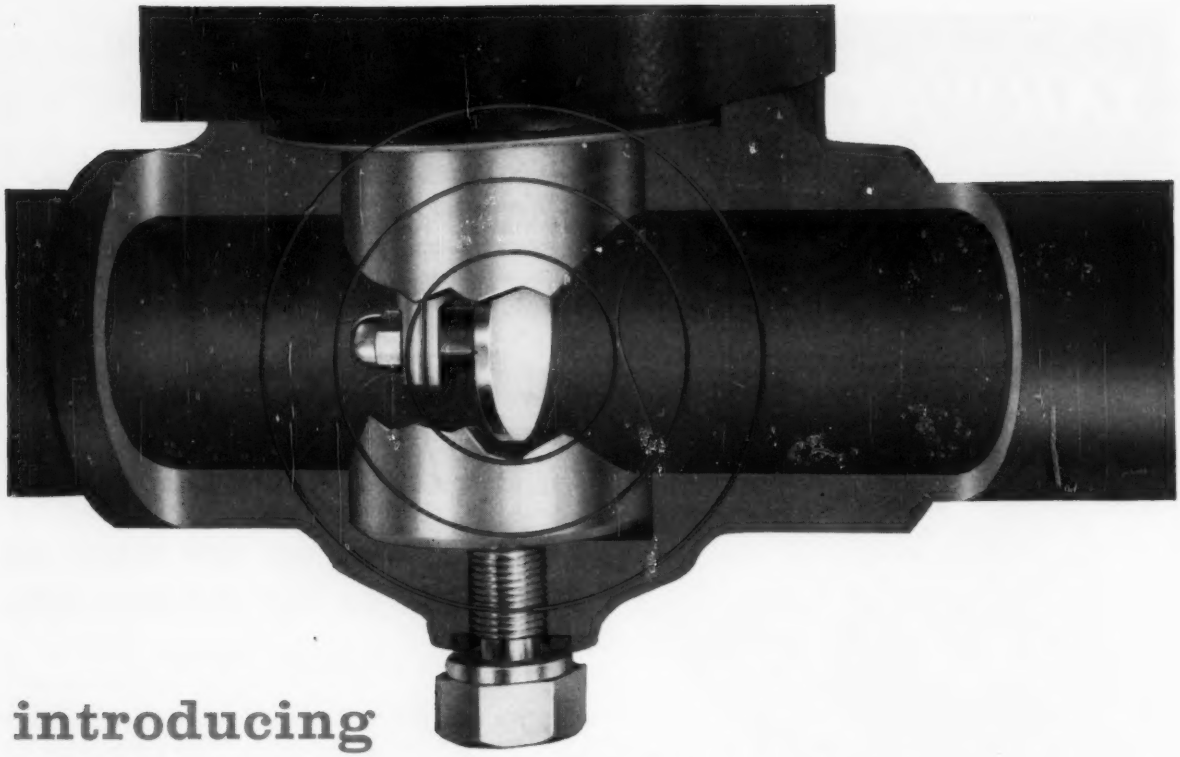
NO OTHER STEAM TRAP COMBINES SUCH COST-SAVING, WORK-SAVING FEATURES

All stainless steel construction, woven stainless steel strainer screen, replaceable trap valve-seat assembly, Allen wrench-operated blow-down valve—make maintenance easy.

Small size, light weight, good for all pressures 8 to 600 psi—make installations simpler.

Try this trap on your steam main drips, steam tracer lines, meter boxes or any other of thousands of light condensate load applications. Call your nearby Yarway distributor today—or write us for more details.

For more data on advertised products, use Readers' Service Cards, last page.



introducing the Foxboro Target Flow Meter

new, improved way to measure the "tough ones" ... heavy oils and viscous liquids to 750° F— installs directly in line ... no pressure taps to foul or plug up—high repeatability—low maintenance—write for TI 37-84a, or contact your Foxboro Field Engineer.

The Foxboro Target Meter is installed directly in the flow line. A stainless steel "target," extending into flow stream, senses mechanical force of fluid pushing against it. Force is then converted to a pneumatic signal and transmitted to a remote recorder or controller.

FOXBORO
REG. U.S. PAT. OFF.

THE FOXBORO COMPANY
741 Neponset Ave., Foxboro, Mass.

ORBIT

FORGED STEEL ASA CLASS VALVES NOW AVAILABLE

FOR 400° Fahr. MAXIMUM WORKING TEMPERATURES

FULL ROUND OPENING — SCREW AND FLANGED END
VENTURI OPENING — FLANGED END ONLY

The maximum rated working temperature for Orbit's standard line of ASA class valves has been increased from 250° Fahr. to 400° Fahr.
Prices for these valves remain the same.

IN ADDITION Orbit ASA class valves are now available for 450° Fahr. Maximum rated working temperatures in 150-300-400-600 lb. class.

Full round opening — screw & flanged end
Venturi opening — flanged end only.

Prices Are Now Available For These Valves

ORBIT VALVES ®

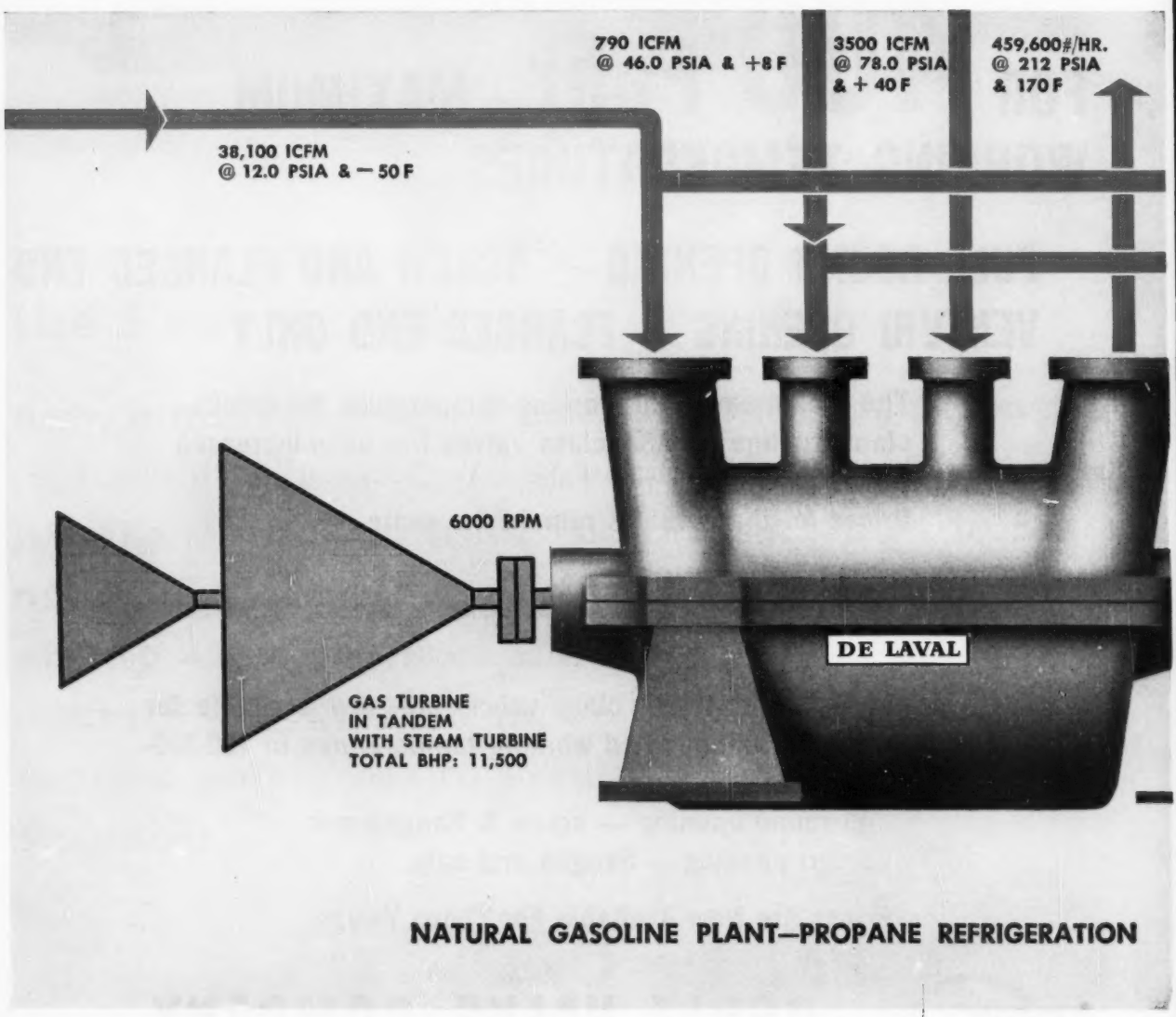
ORBIT VALVE COMPANY

P. O. BOX 699
PHONE LUther 4-4761

TULSA, OKLAHOMA
TWX TU 925

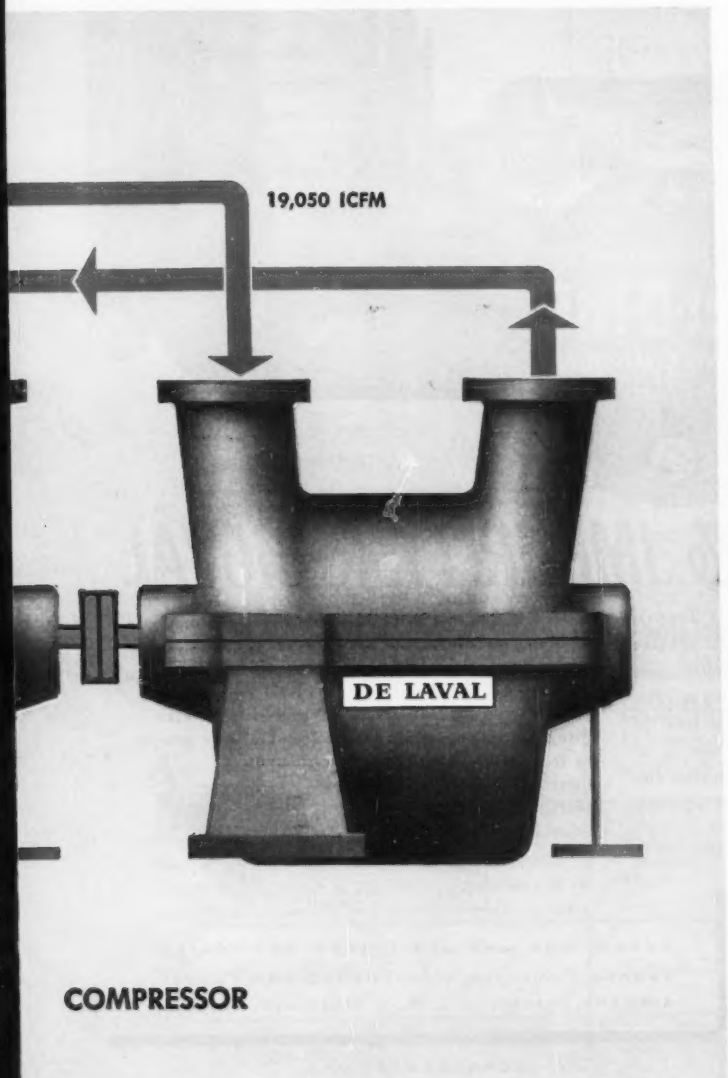
For more data on advertised products, use Readers' Service Cards, last page.

Unique arrangement of compressors demonstrates



NATURAL GASOLINE PLANT—PROPANE REFRIGERATION

centrifugal
DE LAVAL design flexibility



COMPRESSOR

Here is a good example of De Laval design flexibility. In this centrifugal compressor installation the customer wanted to use gas turbine drive because it would provide the most economical use of process fuel. But no single flow compressor design could operate at gas turbine speeds. De Laval creative engineering solved this problem by splitting the flow into two units and several stages as illustrated on these pages.

You can count on De Laval for flexible approaches to engineering problems. We have built high capacity and special purpose centrifugal compressors to meet the special requirements of the petroleum, petrochemical and chemical industries. Why not benefit by our more than 40 years of experience in solving gas compression problems?

Send for De Laval Bulletin 0504.

DE LAVAL STEAM TURBINE COMPANY
811 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-231

For more data on advertised products, use Readers' Service Cards, last page.

another
TRETOLITE SERVICE
report

Treat charging crude with TRET-O-LITE Desalting Chemicals...

...GET 98-100% IMPURITY REMOVAL

Treating the crude charge stream with TRET-O-LITE* Desalting Chemicals keeps it 98-100% salt-free —and removes silt, silica, iron oxide, iron sulfide, and significant amounts of catalyst-poisoning arsenic, as well. Maintaining this remarkably low level of impurities allows refinery equipment to operate at peak efficiency, substantially reduces down-time due to fouling and corrosion damage, and produces better product quality.

*Registered trademark, Petrolite Corporation

TD-60-2

The Man in the Red Car is an expert on refinery desalting problems. Ask him to conduct laboratory tests that will determine the proper formulas and quantities of TRET-O-LITE required for desalting your particular crude oil stocks. Progressive refiners throughout the world rely on Tretolite assistance to treat more than 1,500,000 barrels of crude daily—at an average cost of 1.3 mills per barrel.

Equipment for Tretolite chemical desalting, as well as Petreco electric desalting, is designed and distributed by Petreco Division of Petrolite Corporation.

PETROLITE
CORPORATION

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For more data on advertised products, use Readers' Service Cards, last page.

Refractory Castables are SPECIALIZED

Which are best to use in refinery units?

Naturally, the type of refractory castable selected depends upon the specific service. B&W makes a line of specialized refractory castables which are being widely used in catalytic reformers and catalytic cracking units, as well as in furnaces, ducts and stacks. For easy reference, here are some typical applications together with the recommended B&W Refractory Castables. Bulletin R-35B contains complete information on B&W Refractory Castables. Send for your copy to: The Babcock & Wilcox Co., Refractories Division, 161 East 42nd Street, New York 17, N. Y.

APPLICATION	DESIRABLE PROPERTIES	RECOMMENDED B&W CASTABLES
Linings of catalytic reformers	Low iron — high strength Low iron — good insulation Extremely low iron — extra strength Extremely low iron — good insulation	Kaocrete A Kaolite-20-Gun Kaocrete LI Kaolite
Lining desulphurizers	Good workability	Kaocrete B
Catalytic cracking units, reactors, regenerators and transfer lines	Extra abrasion and erosion resistance.	Kaocrete D
Heads of reactors and regenerators	Plasticity, excellent workability.	Kaocrete B
Insulation for furnace floors	Good insulation, light weight	Kaolite-20-Gun Kaolite-22-Gun
Tube sheets of heaters	Good insulation, light weight	Kaolite-20-Gun Kaolite-22-Gun
Burner blocks	High temperature use limit, refractoriness and spalling resistance.	Kaocast
Openings where doors and other points are subject to mechanical abuse	Extra abrasion and erosion resistance	Kaocrete D
Furnace doors	Good insulation, light weight	Kaolite-20-Gun Kaolite-22-Gun
Ducts and stacks	Good insulation, light weight	Kaolite-20-Gun

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

R-562A

RIDGID No. 2-S
Spiral Reamer

⅛" to 2" Capacity... Self-Feeding for Least Effort

For Smooth, Easy Reaming it has to be

RIDGID®

No. 2
⅛" to 2"
Capacity

No. 3
⅜" to 3"
Capacity

RIDGID
"LonGrip"
Reamers

No Thinned or Flared Walls

Take your choice–Spiral or "LonGrip"–you can't beat these RIDGID Reamers. For hand reaming, you probably prefer the effortless self-feeding Spiral; for power use, the "LonGrip" five-fluted reamers. Heat-treated cutting edges offer extra-long service . . . will not dig in and thin or flare walls. All RIDGID Ratchet Reamers come equipped with handle.

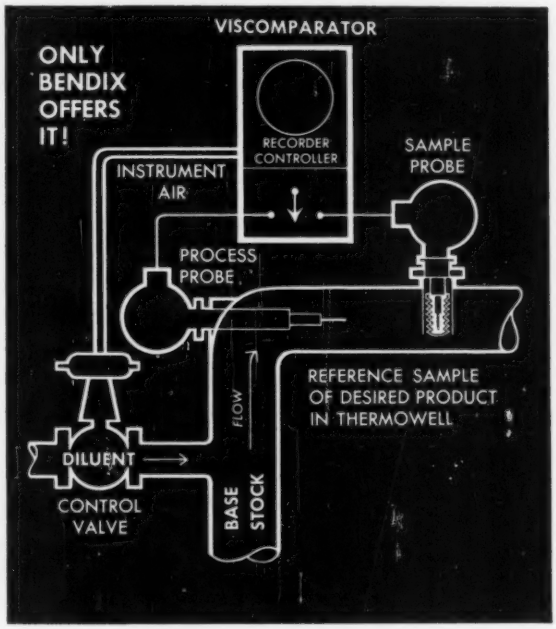
Your Supply House has them. For smoother, faster reaming, order yours today.

RIDGID®

The Ridge Tool Company • Elyria, Ohio, U.S.A.

BENDIX® VISCOMPARATOR®

Provides precise, continuous viscosity control for fuel oil blending, asphalt cutback



The Bendix Viscomparator* is a highly efficient blending process control instrument. It provides continuous and accurate measurement and control of liquids to assure specification viscosity.

A computer and control unit receive signal information from probes in the reference sample and the process sample. A recorder supplies visual indication of viscosity agreement. When difference signals are received, the control unit automatically provides proportional, reset, and rate action to effect the desired control of the process variable.

Temperature compensation is built into the Viscomparator's design. The sensing element is rugged—withstanding up to 650°F. and 1,000 psi.

The Viscomparator is ideally suited to fuel oil blending, asphalt cutback, and similar petroleum processing operations. With a Viscomparator Multipoint Unit, additional probes may be used for multiple-operation control.

For complete information about this precise viscosity control system, write Dept. W10.

*TRADEMARK

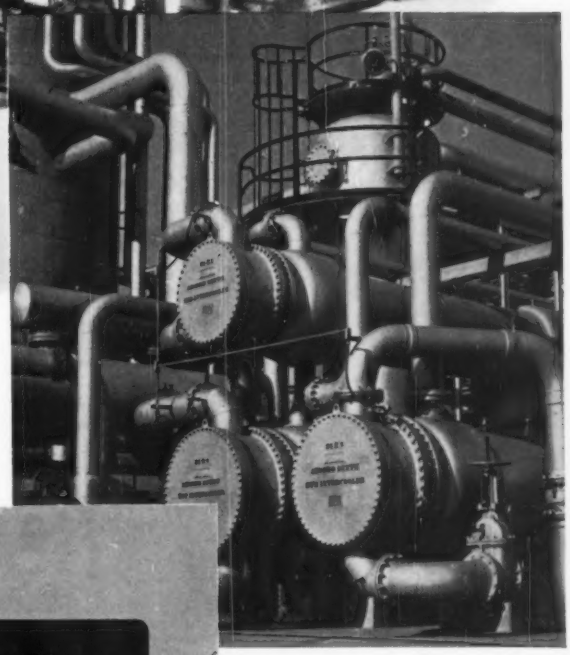
Cincinnati Division
3130 WASSON ROAD, CINCINNATI, OHIO

THE Bendix CORPORATION

Export Sales and Service: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario

where trouble-free performance is a matter of pride...

TIDEWATER OIL DELAWARE REFINERY



many heat exchangers are tubed with...

SCOVILL ®

"the refinery of the future"

HEAT EXCHANGER TUBE

Tidewater Oil Company's showplace installation in DELAWARE, first in a new generation of oil refineries and the largest ever built at one time, also features some of today's finest examples of modern heat.exchanger equipment.

The plant was engineered and designed by Tidewater and C. F. Braun & Co., who were also the builders. Selection of Scovill Cupro-Nickel, 30% Heat Exchanger Tube was based on a well-proved formula for trouble-free heat exchanger performance . . . Scovill craftsmanship in tube production plus Scovill Technical Services.

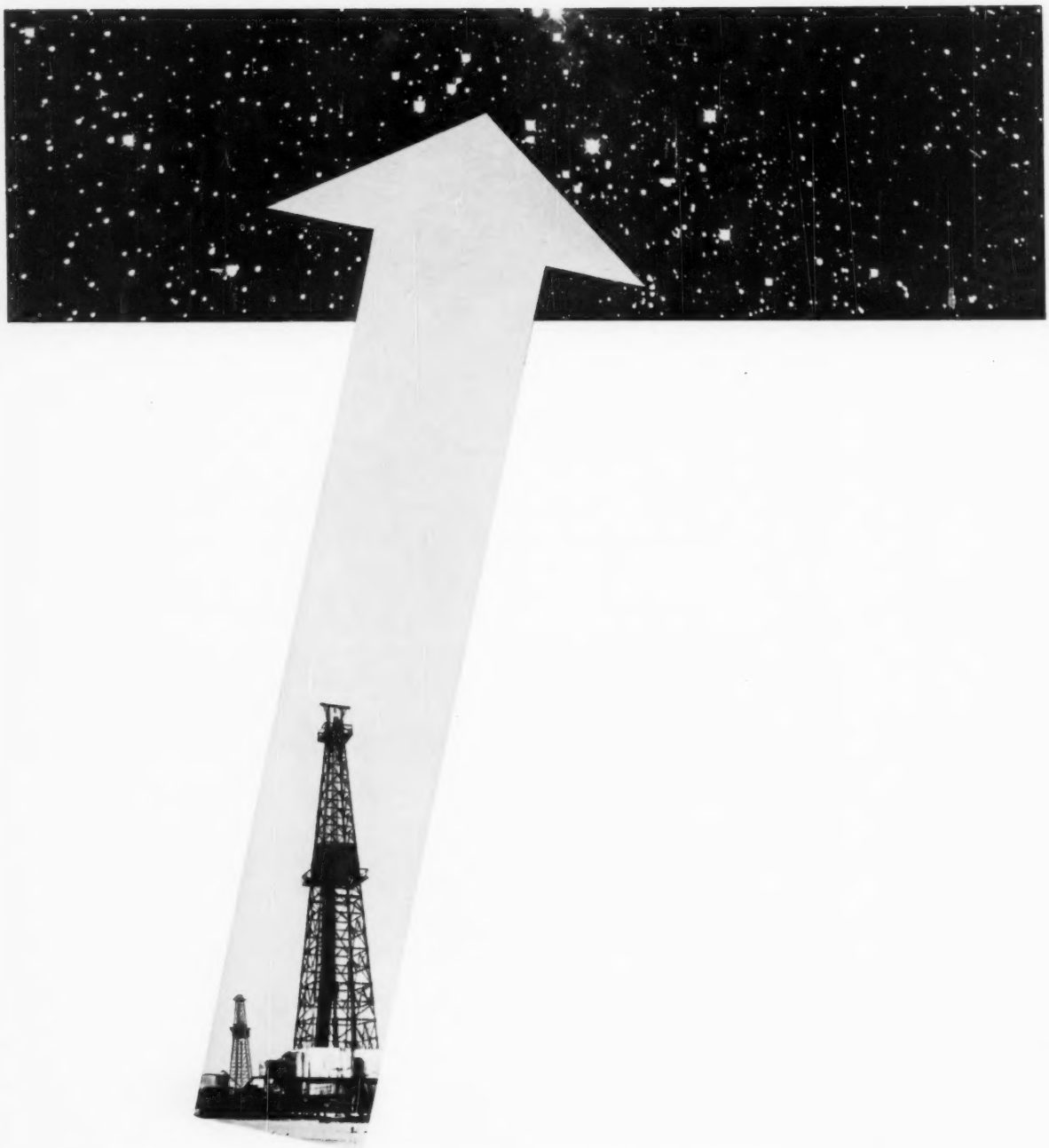
If you are designing, building or operating heat exchangers, it will pay you to discuss trouble-free performance with Scovill.

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . .
Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone Plaza 4-1171.

58CTB



"Petrochemical research is making vital contributions to national defense and the conquest of space. At Esso Research scientists have been at work on the synthesis of compounds that will provide high-energy propellants for missiles and space vehicles. Starting with petroleum-derived hydrocarbons, as well as other compounds of the lighter elements, they are creating new propellant ingredients that will yield a greater thrust per pound." — M. J. Rathbone, President

ESSO

Standard Oil Company (New Jersey)

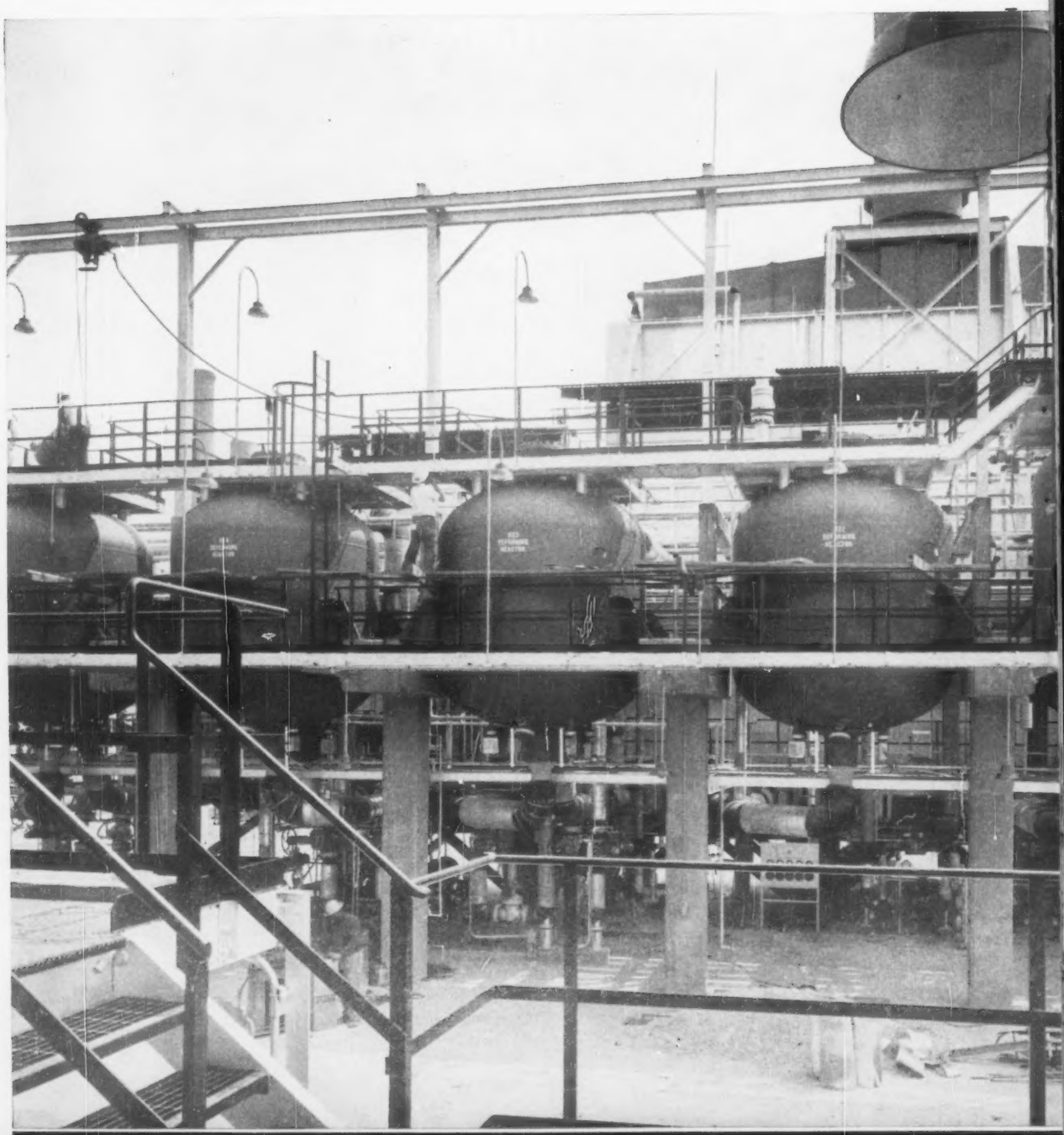
(PRINCIPAL U.S. OPERATING AFFILIATE: HUMBLE OIL & REFINING COMPANY)

HOW A MAJOR REFINERY SOLVED ITS COOLING WATER PROBLEM

DEARBORN CHEMICAL COMPANY

General Offices: Merchandise Mart, Chicago 54 • Dallas • Des Plaines, Ill. • Ft. Wayne • Honolulu
Linden, N.J. • Los Angeles • Nashville • Omaha • Pittsburgh • Toronto • Havana • Buenos Aires

Kellogg Know-How Optimizes



Investment in Cat Reforming

WORLD-WIDE RANGE OF INSTALLATIONS SHOWS FLEXIBILITY OF KELLOGG ENGINEERING-CONSTRUCTION SERVICES

To improve octane rating or to meet increased demands for petrochemicals, Kellogg is uniquely equipped to design or erect catalytic reformers to meet any specific need. Combined with Kellogg-designed hydrotreating facilities, cat reforming produces high octane gasoline of superior quality. The reformate is also a rich source of aromatics for petrochemical production.

Feedstocks reformed include light, heavy, and full-boiling virgin naphthas as well as thermally and catalytically cracked stocks which have been selectively pretreated. Products include aromatics such as benzene, toluene, and xylenes plus isobutane and hydrogen.

For further information on how Kellogg can optimize your investment in cat reforming, you are invited to send for an 8-page folder—"Regenerative Catalytic Reforming".

THE M. W. KELLOGG COMPANY

711 Third Avenue, New York

A subsidiary of Pullman Incorporated

Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

KELLOGG REFORMING EXPERIENCE

Heath, Ohio	3,000 BPD
Houston, Texas	24,000 BPD
Bakersfield, California	4,000 BPD
Grand Prairie, Alberta	875 BPD
Antwerp, Belgium	2,500 BPD
Toledo, Ohio	12,000 BPD
Ponca City, Oklahoma	11,000 BPD
Lemont, Illinois	12,000 BPD
Vancouver, B.C.	4,000 BPD
Denver, Colorado	3,800 BPD
Montevideo, Uruguay	3,000 BPD
Concon, Chile	6,000 BPD
Kent, England	10,000 BPD
Dunkerque, France	10,000 BPD
Kwinana, Australia	10,000 BPD
Antwerp, Belgium	10,000 BPD
El Palito, Venezuela	6,500 BPD
Fremantle, W. Australia	6,000 BPD
Amarillo, Texas	5,000 BPD
Dinslaken, Germany	12,500 BPD
Izmit, Turkey	2,500 BPD*
Karachi, Pakistan	2,250 BPD*
Texas City, Texas	22,300 BPD
Wood River, Illinois	9,000 BPD
Baytown, Texas	20,000 BPD
Pointe aux Trembles, Quebec	4,500 BPD
Texas City, Texas	7,500 BPD
Ponca City, Oklahoma	3,850 BPD
Baytown, Texas	16,500 BPD
Oleum, California	8,000 BPD
Lockport, Illinois	7,500 BPD
Whiting, Indiana	9,250 BPD
Toledo, Ohio	5,500 BPD
Buenos Aires, Argentina	740 BPD
Destrehan, Louisiana	2,000 BPD
East Chicago, Indiana	12,780 BPD
Lake Charles, Louisiana	17,250 BPD
Whiting, Indiana	30,000 BPD
West Tulsa, Oklahoma	7,500 BPD
Regina, Saskatchewan	3,000 BPD
TOTAL	348,095 BPD

**Future*

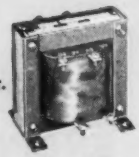
For more data on advertised products, use Readers' Service Cards, last page.

SQUARE D SPIN TOP® ENCLOSURE NOW MORE VERSATILE THAN EVER!

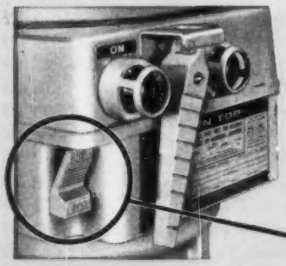
DAMAGE-RESISTING Acme threads. If you've struggled with "banged-up" threads, you'll appreciate this feature. It's always a breeze to put on and take off tanks for installation, inspection or maintenance.

FULL WEATHER PROTECTION • Male threads on collar engage female threads on tank—no external threads to be damaged.

NEW! ***CONTROL TRANSFORMER*** can be mounted in collar. No special-length tanks required.

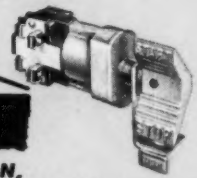


INCREASED WIRING SPACE • Four conduit openings standard, with through-feed conduit entrances for horizontal tap-offs optional.



NEW! ***SELECTOR SWITCH*** is made in one piece, installs simply by threading into opening provided in enclosure. One-piece construction permits pre-testing before shipment.

NEW! ***RECESSED CONTROL STATIONS*** like the reset button are out of the way, have no protrusion to break or bend accidentally.



NEW! ***PUSHBUTTON,*** like the selector switch, features one-piece construction for easy installation. Heavy-duty contacts and rugged mechanism assure long life.

NEW! ***BRILLIANT PILOT LIGHT*** is visible from all angles and provides easy bulb change. Enclosure available with either one or two factory-mounted lights or can be furnished with plugged holes for field installation. Stainless steel thread-in-thread construction gives corrosion-resistance and easy servicing.

EASY TO INSTALL with *slide and hook* mounting arrangement for interior equipment—a Square D "exclusive." Takes the hard work out of the installation job.

STRONG AND LIGHTWEIGHT construction. Complete enclosure is cast aluminum. All operating shafts are stainless steel, thread-in-thread, for the best in corrosion resistance.

Square D *is Better in So Many Ways!*

When you buy from Square D, you not only get all the benefits shown above—you also are buying from the only manufacturer who builds both the enclosure and the starter, giving you unit responsibility. Moreover, Square D offers better stocks, better on-the-spot service. That's why it makes sense to insist on Square D Spin Top enclosures for your hazardous location applications.

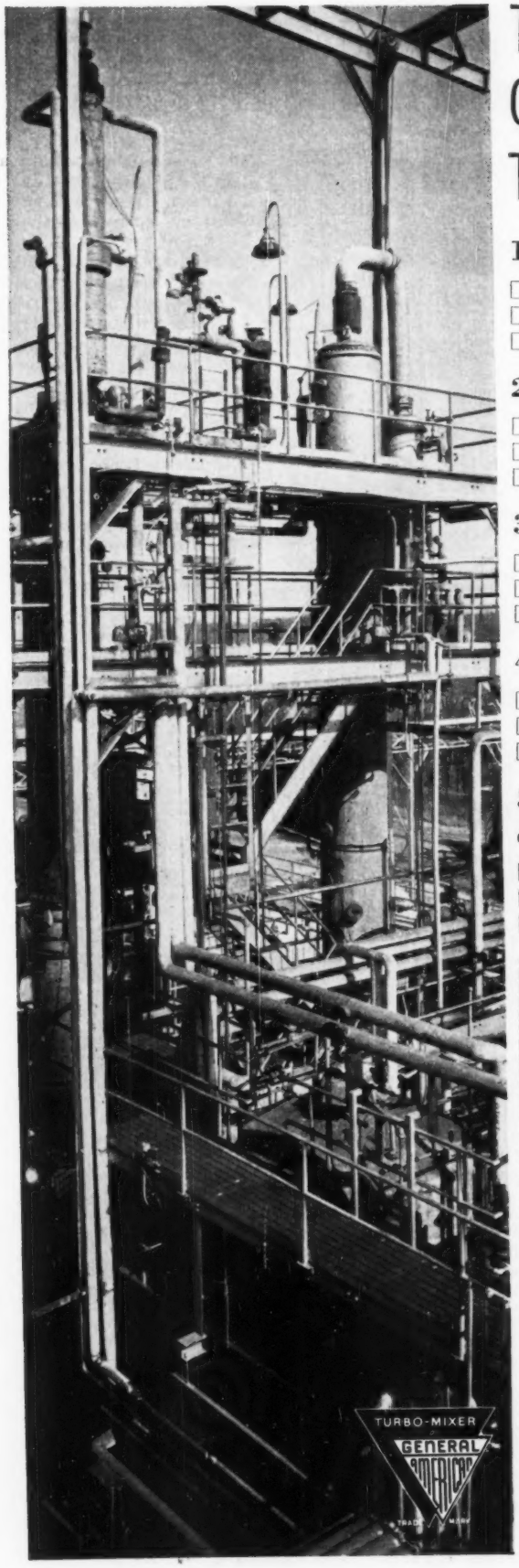
4 ENCLOSURE SIZES ACCOMMODATE NEMA SIZES 0 THROUGH 5

Square D Spin Top enclosures are NEMA 3 (weatherproof), NEMA 4 (watertight), NEMA 7 (explosion-proof) and NEMA 9 (hazardous locations) for Class I, Group C and D; and Class II, Groups E, F and G service.

Write for Bulletin 9990. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

wherever electricity is distributed and controlled



TRY THIS SIMPLE QUIZ ABOUT THE **RDC** COLUMN

1. ***R.D.C. stands for***

- ☐ a) Rapid Dispersion Column
- ☐ b) Recycle Displacement Column
- ☐ c) Rotating Disc Contactor

2. ***RDC Columns are made by***

- ☐ a) 6 different manufacturers
- ☐ b) by one manufacturer
- ☐ c) by 10 manufacturers

3. ***The RDC column has been used for***

- ☐ a) Separation of Hafnium from Zirconium
- ☐ b) Caustic extraction of acids from organics
- ☐ c) Caffein and vanillin extraction

4. ***The RDC column can be used for***

- ☐ a) liquid-liquid extraction
- ☐ b) liquid-solid extraction
- ☐ c) liquid-slurry extraction

5. ***The RDC column has which of these advantages***

- ☐ a) High volumetric efficiency
- ☐ b) No interstage coalescing or external settling
- ☐ c) Low power requirements

Answers

1. (C) Rotating Disc Contactor

2. (B) RDC columns are made only by the Turbo-Mixer Division of General American Transportation Corporation for all industries except petroleum. Manufacture is licensed under Shell Development Corporation patents.

3. (A), (B) and (C). For a complete list of typical systems in service, contact General American.

4. (A), (B) and (C) again. The RDC column is one of the most versatile tools available for extraction processing.

5. (We did it again—all three are correct).

If you'd like more information on the RDC column and the many advantages it offers, send for Bulletin T-1159. You'll find it pays to plan with General American.

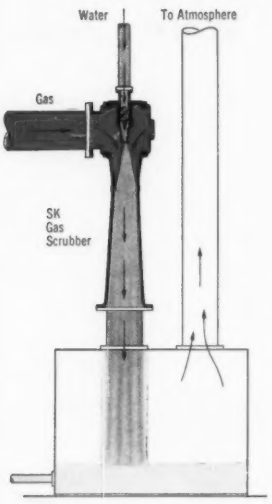
Process Equipment Division—Turbo-Mixers
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 3, Illinois
Offices in principal cities

LET SK JET EJECTORS SIMPLIFY YOUR JOB

SK Jet Ejectors are outstandingly simple and reliable. There are no rotating parts to break, none to maintain. Jet ejectors are compact, low in cost. Because of their uncomplicated design, they can be made in many corrosion and erosion resistant materials. Easy to install and requiring little attention, they can be located in remote and inaccessible places. And, most often, they will perform two or more functions at the same time. Pump *and* heat. Entrain *and* scrub. Pump *and* mix. Compress *and* move.

SK Jet Ejectors are worth knowing more about. Ask for Bulletin J-1. It gives brief data on types and functions.

SK Ejector-Venturi Scrubbers
SOLVE FUME PROBLEMS



SK Gas Scrubbers operate on the jet principle. Use a pressure liquid, issuing through a spray nozzle, to create a draft, draw gases, vapors, dusts into the unit, scrub them, and discharge clean air.

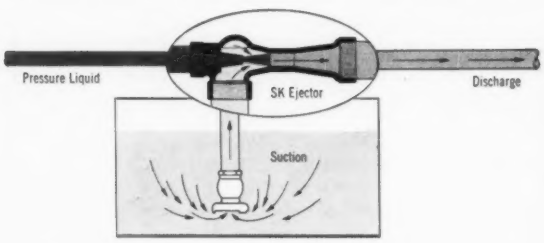
These scrubbers are (1) *economical*—low in initial and operating cost compared with other types; (2) *efficient*—see data in Bulletin 4R; (3) *readily available*—stocked in popular sizes in Pennsylvania, Texas, California; (4) *adaptable*—made and stocked in cast iron, asbestos-filled resin, PVC, and stoneware to meet service conditions.

For details—ask for Bulletin 4R

SK Liquid Jet Ejectors
PUMP AND MIX SIMULTANEOUSLY

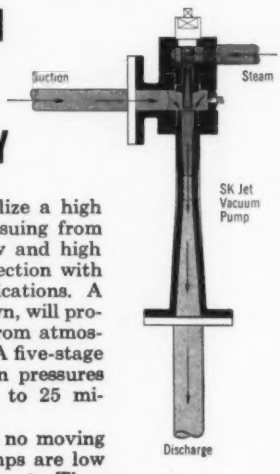
SK Liquid Jet Ejectors utilize the kinetic energy of a liquid under pressure to entrain, mix, and pump liquids or handle slurries and granular solids. Uses vary from pumping out a sump to mixing chemicals in proper proportions.

Some user benefits: (1) *economy*—a 2-inch, bronze unit costs only $51.00; (2) *maintenance-free service*—simple construction and lack of moving parts makes supervision unnecessary; (3) *availability*—stocked in popular sizes in Pennsylvania, Texas, California; (4) *adaptability*—made and stocked in cast iron, bronze, stainless steel, asbestos-filled resin, PYREX brand tubing, and PVC.



For details—ask for Bulletin 2M

SK Steam Jet Vacuum Pumps
PRODUCE HIGH VACUUM ECONOMICALLY



SK Vacuum Pumps utilize a high velocity jet of steam, issuing from a nozzle, to provide low and high vacuum service in connection with numerous process applications. A single-stage unit, as shown, will provide suction pressures from atmosphere to 1.5 in. Hg abs. A five-stage unit will provide suction pressures from 0.25 mm Hg abs to 25 microns Hg abs.

Simple in design, with no moving parts, SK Vacuum Pumps are low in cost, economical to operate. They are available in popular sizes in various materials from stock in Pennsylvania, Texas, California.

For details—ask for Bulletin 5E

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.
Phone: MErcury 9-0900 TWX: Cornwells, Pa. 69-U

COUNTRY-WIDE TESTS PROVE HOW TOTCO CONTINUOUS END-POINT ANALYZER CUTS CONTROL COSTS ...INCREASES YIELD

In major refineries from the East Coast to the West, the new Totco continuous End-Point Analyzer has demonstrated its ability to provide better control over product quality and yield. It quickly pays for itself and steps up profits. ■ This sensitive instrument continuously indicates the Engler End Point of a hydrocarbon stock or commodity in an operating range of 200° F. to 700° F. It delivers reproducibility within ±1°F., with results that correlate with ASTM D86 or ASTM D158. And its continuous analysis cuts the usual delays between quality change and compensating plant control... eliminates the time lag of batch analyzers or conventional laboratory tests. ■ Write or call today for further information. Request Bulletin 5900-11.

CASE HISTORY #1

Major Eastern Refinery

Use of the TOTCO End-Point Analyzer enabled this refiner to step up end-point specifications of reformer feed stock by 10°F with safety. Result: increased yield and a saving of over $200 a day. On the basis of this test, six additional Totco units were ordered!

CASE HISTORY #2

Major West Coast Refinery

Both TOTCO's End-Point Analyzer and Initial Boiling Point Analyzer were used here on a narrow-cut solvent. It was found that the analyzers kept yield on grade better than 99% of the time! Previous average with laboratory control was 90%.

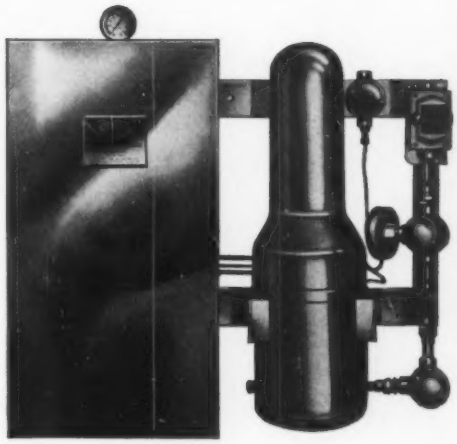
CASE HISTORY #3

Major Mid-West Refinery

In this test, the TOTCO End-Point Analyzer was mounted in a trailer and used on a crude still to control first-cut products on stream. So successful was the test that the company ordered two additional Analyzers for use at other refineries.

TOTCO CONTINUOUS INITIAL BOILING POINT ANALYZER

Totco also manufactures an Initial Boiling Point Analyzer. Write for Bulletin 1259-11 giving details and operating data.



TOTCO

TECHNICAL OIL TOOL CORPORATION

1057 North La Brea Avenue, Los Angeles 38, California • OLdfield 4-1763

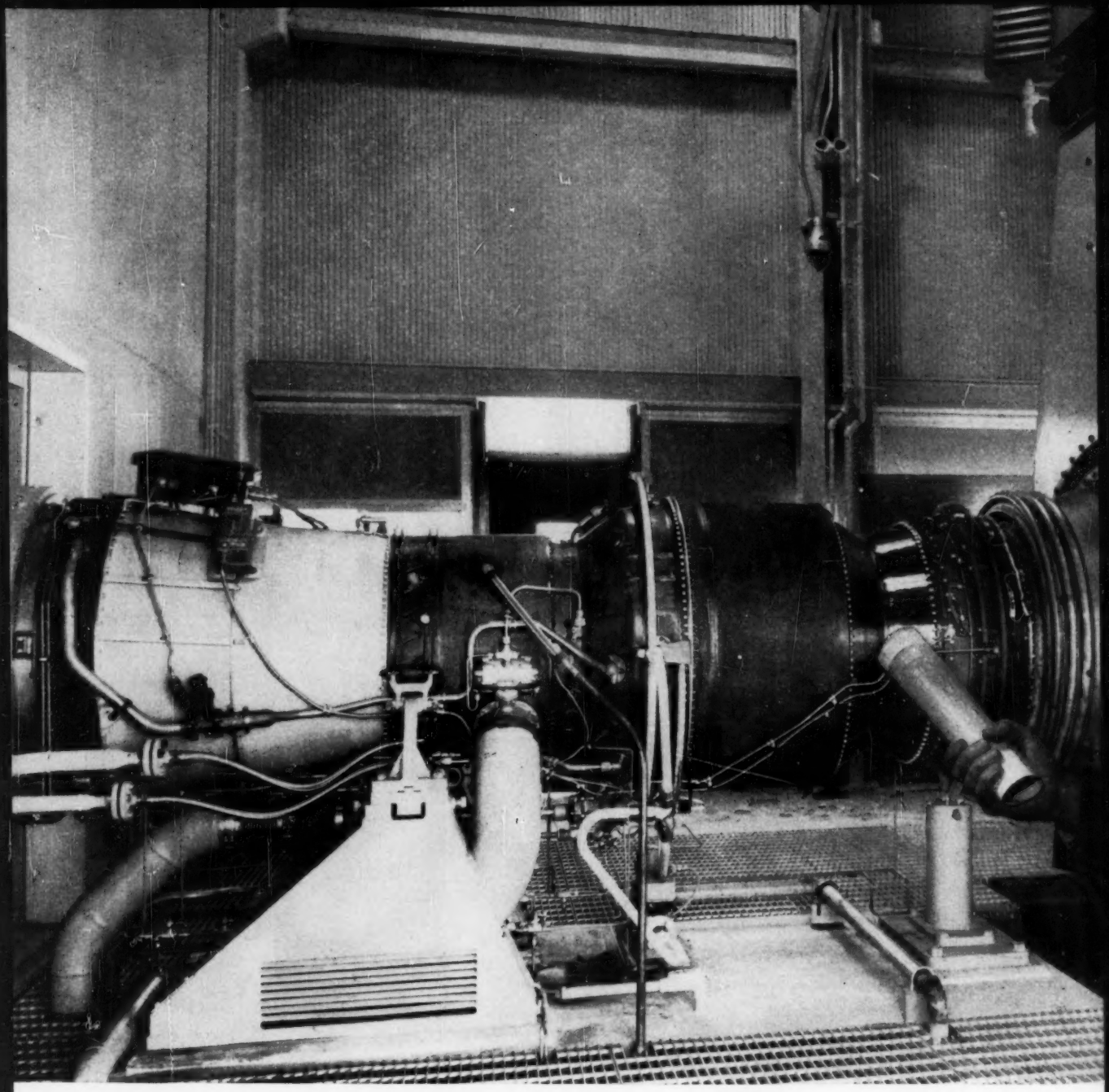
Manufacturers of Precision Instruments since 1929

CASE HISTORY #4

Major Western Refinery

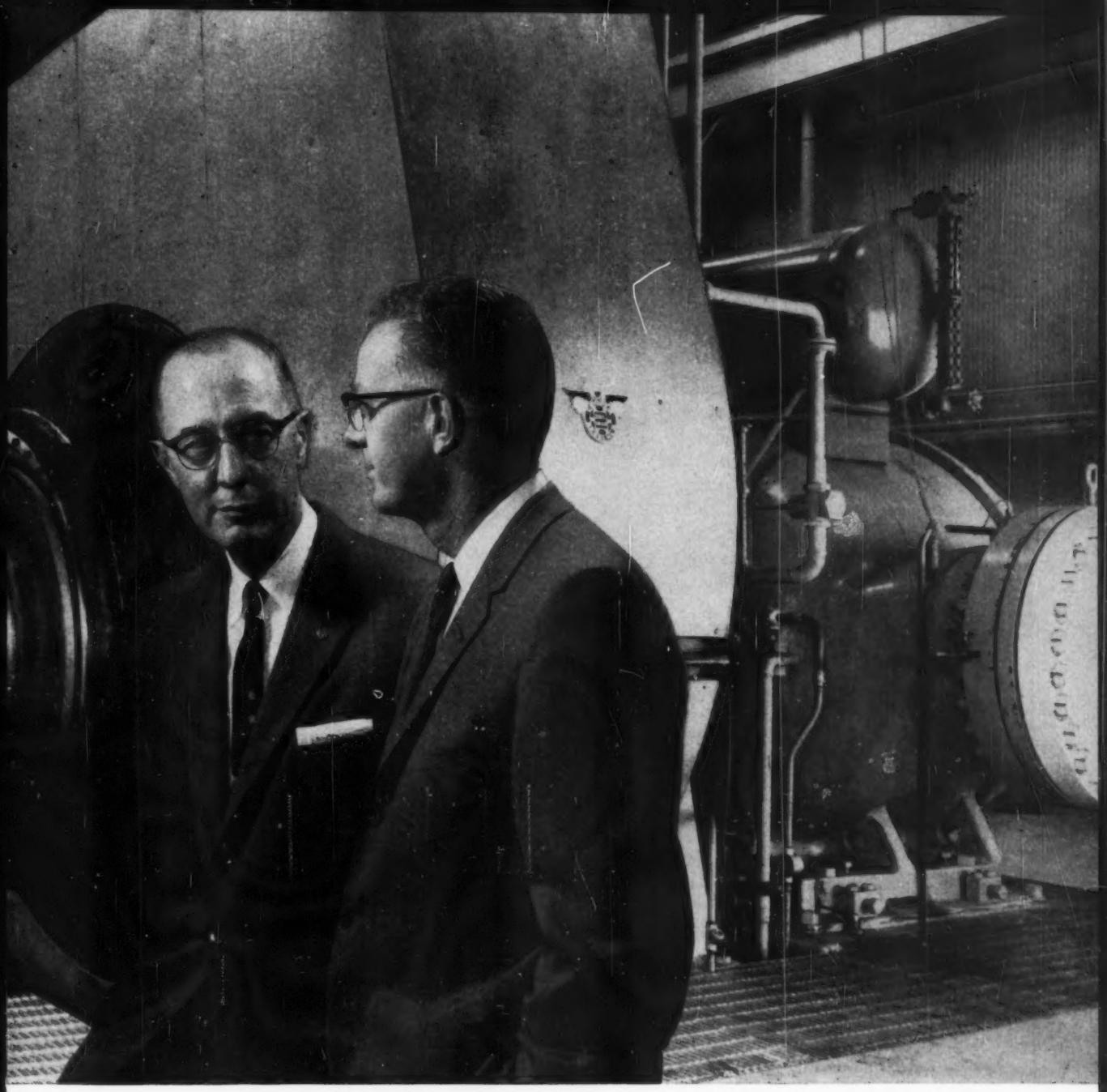
Demonstrating the versatility of the TOTCO End-Point Analyzer was this test where it was used to control the cut on heavy naptha. The test was a money-saving success, and the firm has since ordered additional units.

For more data on advertised products, use Readers' Service Cards, last page.



R. L. Boyer, *Vice President and Director of Engineering, and* W. B. Boyum, *Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report . . .*

World's first jet powered gas turbine is now on the job



YOU are looking at a revolutionary new concept in industrial power. This Cooper-Bessemer 10,500 hp RT-248 gas turbine with a modified Pratt & Whitney Aircraft J-57 jet engine introduces new, drastic economies in plant construction, operation and maintenance. Shown here on the job at the Clementsville (Kentucky) Compressor Station of Columbia Gulf Transmission Company, this powerful, compact unit has taken on the total gas-boosting load of the station, operating 'round the clock. Find out how this outstanding joint development of Cooper-Bessemer and Pratt & Whitney Aircraft can fit into *your* plans for compressors, generators and other rotating machinery. Call our nearest office.

BRANCH OFFICES: Grove City • New York • Washington Gloucester • Pittsburgh • Detroit • Chicago • Minneapolis • St. Louis Kansas City • Tulsa • New Orleans • Shreveport • Houston Greggton • Dallas • Odessa • Pampa • Casper • Seattle San Francisco • Los Angeles • SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd. . . . Edmonton • Calgary • Toronto • Halifax Stratford • C-B Southern, Inc. . . . Houston • Cooper-Bessemer International Corporation . . . New York • Caracas • Anaco • Cooper-Bessemer, S.A. . . . Chur, Switzerland • The Hague, Netherlands Mexico City • The Rotor Tool Company, Cleveland

Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

take NEWTHERM on test!

Test its STRENGTH

NEWTHERM is unusually strong and rigid—a feature of special importance in the larger, more vulnerable sections. Put a sample section or slab on part of your plant and *prove for yourself* its outstanding ability to withstand impact and water damage. See how it withstands rough handling in transit and erection, minimising breakage in shipment and erection by unskilled labour at the most remote sites.

Test its MOISTURE RESISTANCE

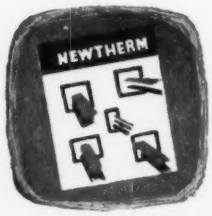
Even totally immersed in water, NEWTHERM retains much of its strength and rigidity. It does not become deformed when in contact with water, thus work-in-progress need not be covered. Especially on contracts where weather conditions would delay the application of insulation – NEWTHERM is the material to use.

Test its LIGHTNESS

Unusually light for such a high-efficiency material, NEWTHERM compares favourably in this respect with other insulants far inferior in strength. That means easier handling and fewer breakages—even the largest section is easily carried in one hand.

Test its EASE OF APPLICATION

Undoubtedly, NEWTHERM is one of the easiest of materials to apply. It is supplied in plastic form and in a wide range of standard-sized sections and slabs, smoothly finished and straight edged for immediate fitting. The finished job is very neat, with minimum joints, and appliers particularly appreciate the handleability of the material – especially in difficult situations.



READ ALL ABOUT NEWTHERM

in a specially prepared booklet. Sizes, compressive strength, thermal conductivity,—this and much more useful information can be on file if you write for your copy now, to the sole manufacturers Newalls Insulation Co. Ltd.

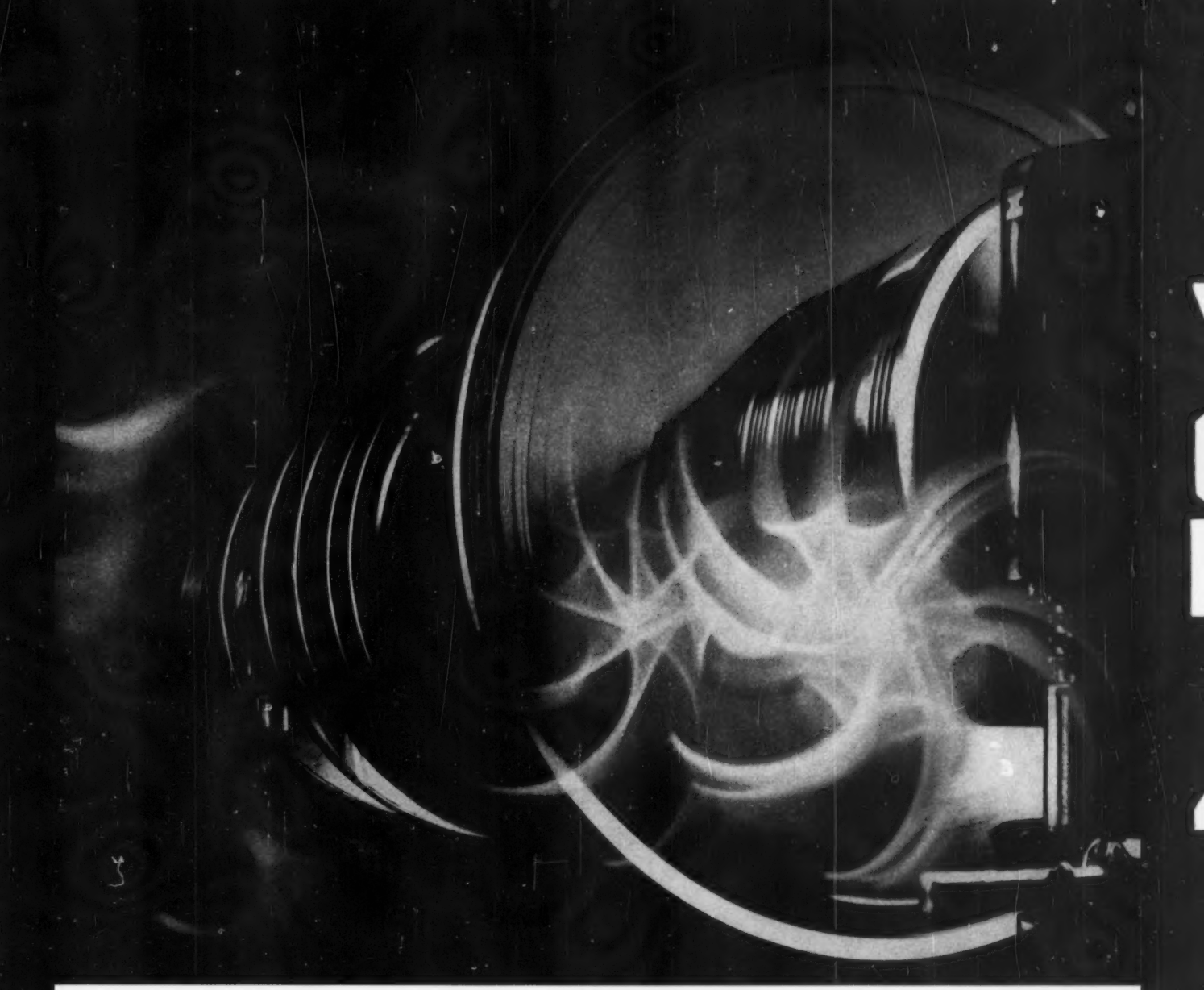
NEWALLS (Reg'd Brand)

***NEWTHERM** calcium silicate insulation*

. . . for temperatures up to 1400°F.

NEWALLS INSULATION CO. LTD.

Head Office: WASHINGTON, CO. DURHAM, ENGLAND.
A member of the TURNER & NEWALL ORGANISATION
Offices & Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL & CARDIFF.
Agents and Vendors in most markets abroad.



Turbine rotor on dynamic balancing machine—special photographic impression

HOW TO BALANCE "n" TURBINE VARIABLES

This rotor was designed in light of the "n" variables that affect turbine design. No one really knows the number—each installation is different. But they begin with steam pressure and temperature, exhaust steam pressure(s), horsepower and speed requirements, controls, efficiency requirements, and, of course, the nature of the individual application.

Balanced properly, these variables will produce extreme reliability—what we at Worthington believe to be the single most important factor in turbine design.

Balancing these factors in design is, of course, the work of power engineers and turbine specialists. But, it is desirable to have *every* person who is engaged in selection, operation and maintenance familiar with the many factors in mechanical drive turbine design. To help those of your people concerned with turbine application we have just prepared "Let's Talk Turbines." It's a primer on API specifications and other subjects such as turbine types, construction, governing systems and lubrication methods. Write Worthington Corporation, Section 48-12, Wellsville, N. Y.

WORTHINGTON

PRODUCTS THAT WORK FOR YOUR PROFIT

Photographed at American Oil Co., (Wood River, Ill., Refinery)

New! A far more versatile hydrogen-treating catalyst

Are you still using conventional cobalt-molybdenum desulfurization catalysts on feedstocks high in nitrogen and polyaromatics? Then it will pay you (in production and profits) to investigate AERO® HDS-3 catalyst!

AERO HDS-3 is Cyanamid's brand-new nickel-molybdenum catalyst. Its biggest advantage is an unparalleled capacity for removing nitrogen and polyaromatics. In life tests, it markedly outperformed—and lasted longer than—conventional cobalt-molybdenum catalysts. It is also superior in sulphur-removal; in improving the color of waxes; in hydrogenation of feedstocks and middle distillates.

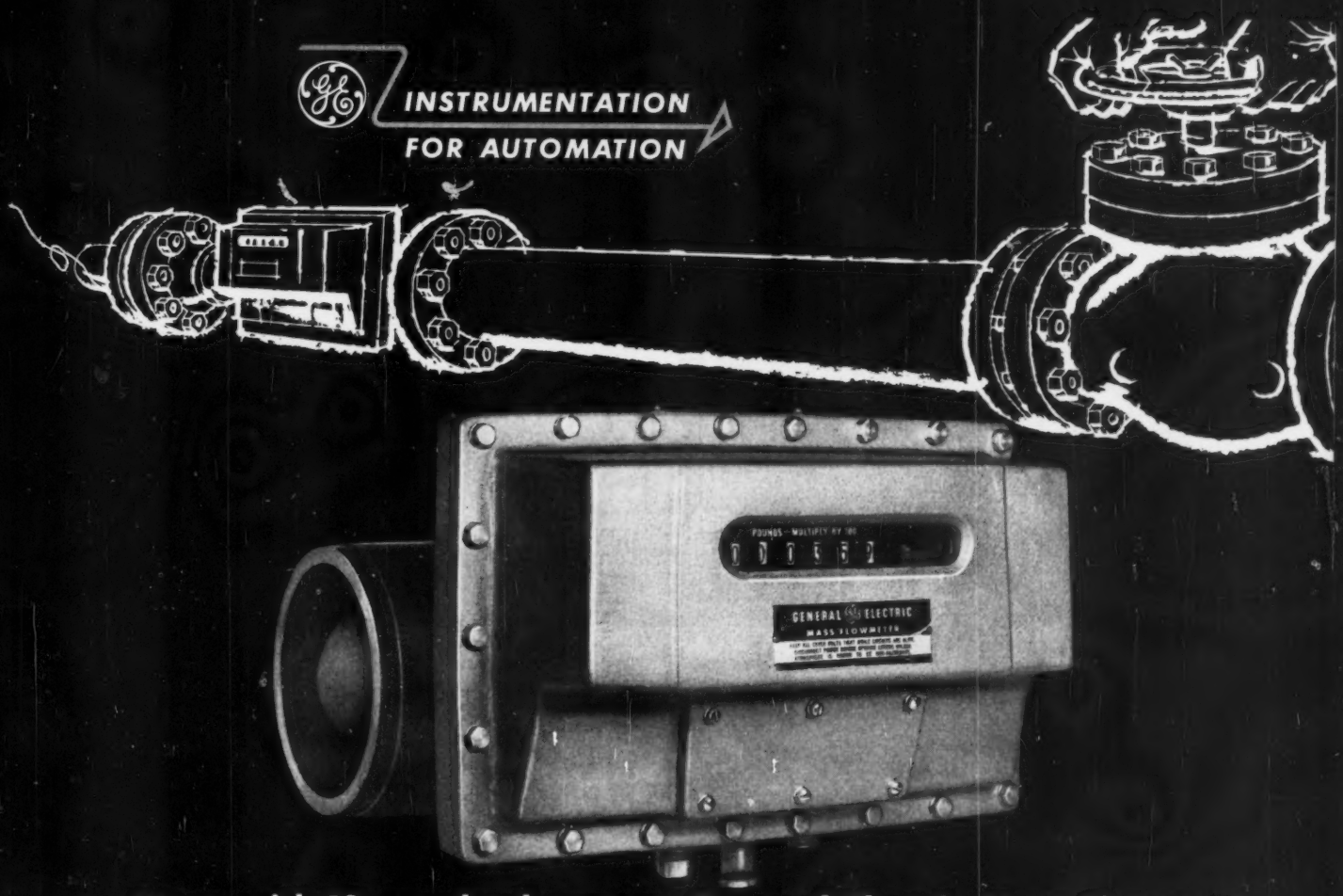
Behind this newest catalyst lies the experience of Cyanamid as a major producer of both catalysts and other chemicals. That experience is yours when you call your Cyanamid salesman—"The Man with the Golden Rule." Ask him—or write us—for the full data on AERO HDS-3.

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, New York

INSTRUMENTATION
FOR AUTOMATION



Now, with 12 standard ranges, General Electric Mass Flowmeter

PERFORMANCE-PROVED

. . . **ON THE LINE!** Today, many companies in the petroleum, chemical, petrochemical and natural gas industries are accurately measuring valuable process fluids directly in pounds with the General Electric True-Mass Flowmeter.

For example, these 12 applications have been performance-proved in actual service metering:

- **air • natural gas • alcohol • vinyl chloride**
- **freon • ammonia • liquid carbon dioxide**
- **ethylene • liquid petroleum gas • naphtha**
- **jet fuel • methane hydrogen mixtures**

(*Many more to come—let us know what your specific application is.*)

NEW ACCESSORIES FOR APPLICATION FLEXIBILITY:

Now, you can control batch blending accurately on a system basis with this flowmeter and new accessories which include:

counters—permit remote digital readout; **pre-set counters**—for automatic blending; **ticket and tape printers**—allow permanent and remote recording of flow.

AND *ALL* MODELS FEATURE:

- Accuracy independent of variations in density, pressure, viscosity and temperature
- Completely self-contained, self-integrating unit
- Low pressure drop
- Accuracy unaffected by fluctuation in power supply voltage and frequency
- Long-term stability for minimum maintenance and infrequent field calibration
- Quick response to rapid changes in flow without overshoot or lag
- Measurement in pounds—eliminates tedious conversions

DO YOU HAVE AN APPLICATION for this revolutionary new instrument? Chances are you do, and we'd like to know about it. Contact your nearby G-E Sales Office, or write directly to General Electric Co., Section 599-03, Schenectady 5, N. Y. Be sure to ask for bulletin GEA-6925A. In Canada, contact Canadian General Electric Co., 940 Lansdowne Avenue, Toronto 4, Ontario. On applications in the natural gas industry, contact Black Sivalls and Bryson, Inc., P.O. Box 1714, Oklahoma City, Okla.

INSTRUMENT DEPARTMENT

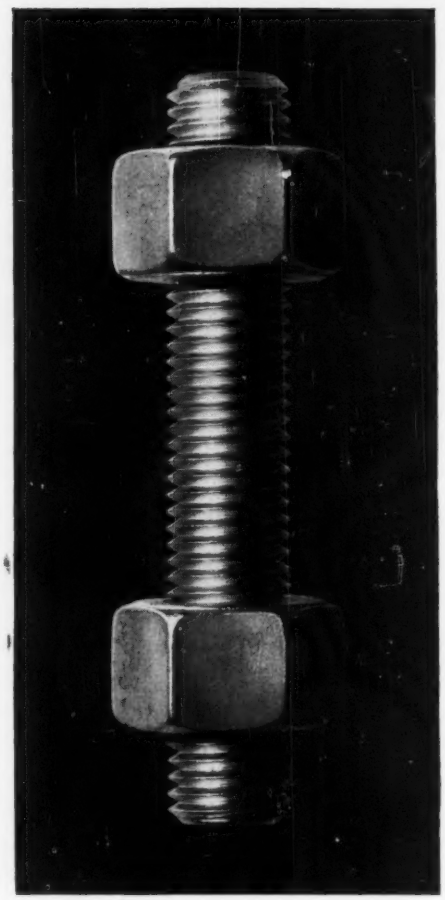
GENERAL ELECTRIC

Low-cost bolting for high-temperature connections . . .

Steel

for Strength . . . Economy . . . Versatility

Bethalume-coated alloy studs and quenched nuts



For high temperatures and in severely corrosive refinery service—you can rely on Bethlehem's Bethalume-coated continuous-thread alloy studs and quenched nuts. This is because we have *proved* that they have longer service life.

A series of tests, held at temperatures higher than normal refinery conditions, showed virtually no weight change in the Bethalume-coated samples. Another series of tests, conducted in highly corrosive refinery atmospheres, revealed no appreciable corrosion of the Bethalume-coated samples over a four-year period.

Look at the other advantages of Bethalume coating:

1. Double-layer protection: pure aluminum coating on top of a metallurgically bonded, iron-aluminum alloy.
2. Uniform coating.
3. High-temperature galling is minimized.

Full details on how Bethalume coating assures *low-cost* bolting at *high-temperatures* can be obtained from the nearest Bethlehem office. Or simply write a letter or postcard to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA., *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

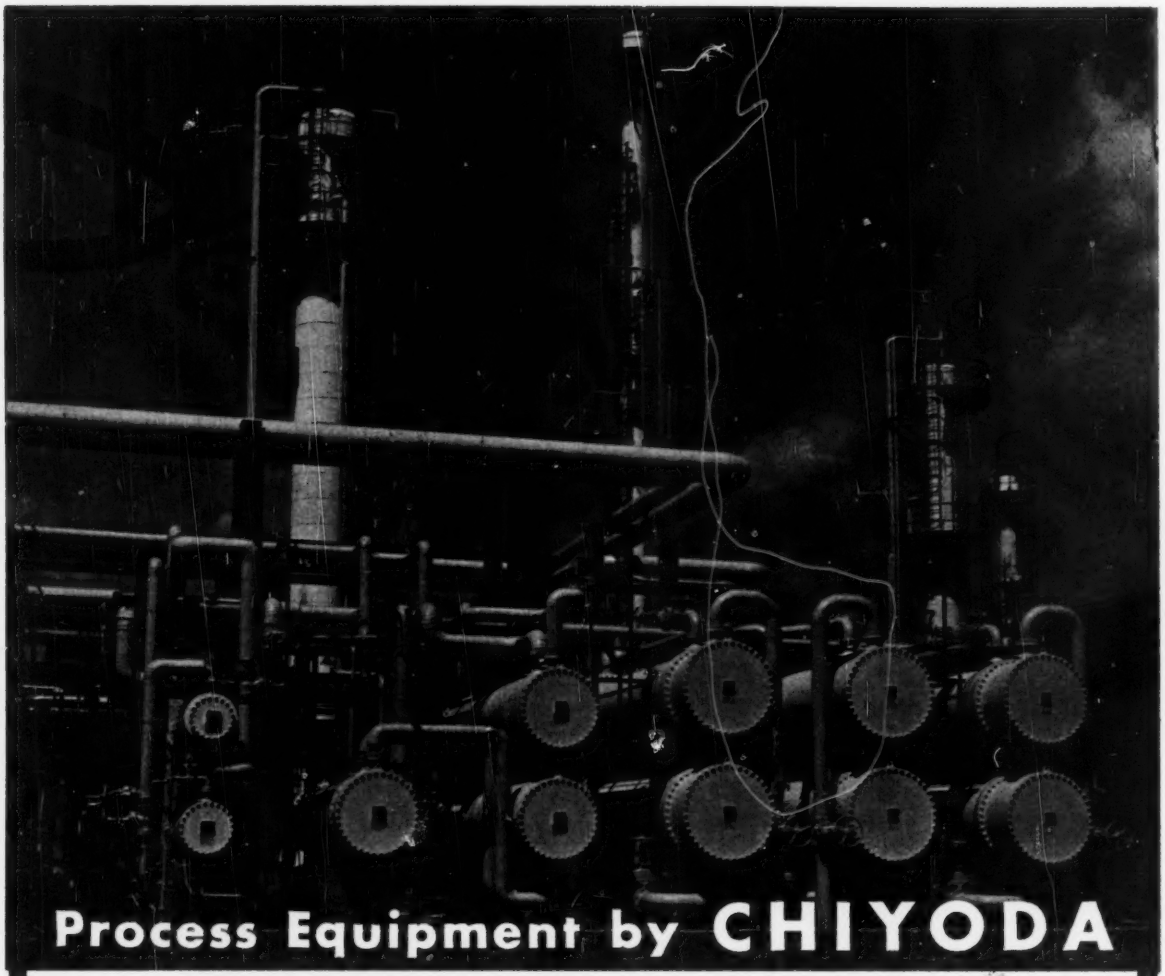
HUMBLE COREXIT

Save time and money previously lost to internal corrosion: use Humble COREXIT . . . COREXIT effectively and economically prevents internal corrosion in pipe still overhead, distillation towers, vapor recovery systems and other refining units. COREXIT will reduce or completely eliminate plugging or fouling. This protection against sludge, scale and corrosion cuts non-productive downtime to a minimum. For complete information on technical services and products, contact your Humble salesman.

HUMBLE

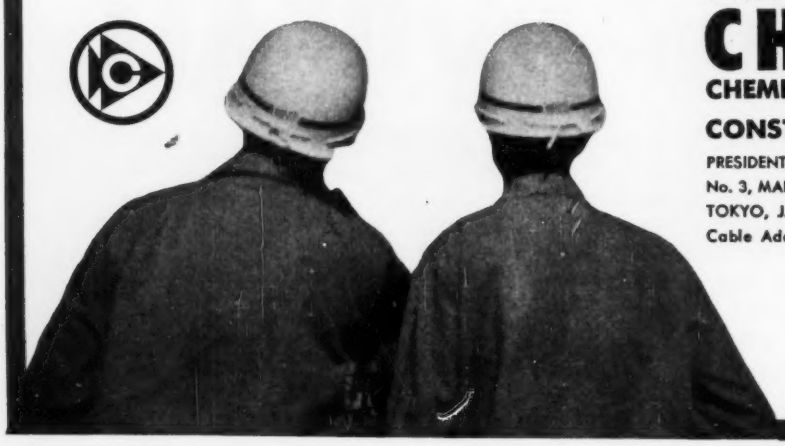
HUMBLE OIL & REFINING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.



Process Equipment by CHIYODA

Heat exchangers, towers, vessels, tanks and other process equipment, large or small, single or by the scores, standard or special, are fabricated at Chiyoda's Kawasaki Factory with the most modern fabricating and testing equipment.
With an integrated organization staffed by specialists in every field plus lower man-hour costs, Chiyoda assures clients of early delivery, low maintenance cost, high operating efficiency and long life.
For your process equipment requirements anywhere in the world, contact CHIYODA.



"Process Plants & Equipment Specialists"

CHIYODA
CHEMICAL ENGINEERING & CONSTRUCTION CO., LTD.

PRESIDENT A. TAMAKI
No. 3, MARUNOUCHI 2-CHOME, CHIYODA-KU,
TOKYO, JAPAN
Cable Address: "CHIYOTAKA TOKYO"

For more data on advertised products, use Readers' Service Cards, last page.

D. I. S. STRIPS 10-INCH SCALE FROM 12-INCH PIPELINE IN JUST ONE DAY!

Dense scale deposits of oxides, sulfides and sulphur—10 inches thick in some places—clogged a 12-inch fuel supply line. Dow Industrial Service engineers stripped every trace of deposits from this 750-foot pipeline—restoring full capacity—in *just 24 hours!*

Solvents and a pipeline pig did the job. But for different conditions, D. I. S. uses other techniques to get the same result. For example, when scale blocked a 24-inch, quarter-mile-long waste line, D. I. S. engineers knocked out the deposits with a special D. I. S.-designed jet mole. Though this underground pipeline was buried 10 feet deep, D. I. S. cleaned it completely in only 16 hours!

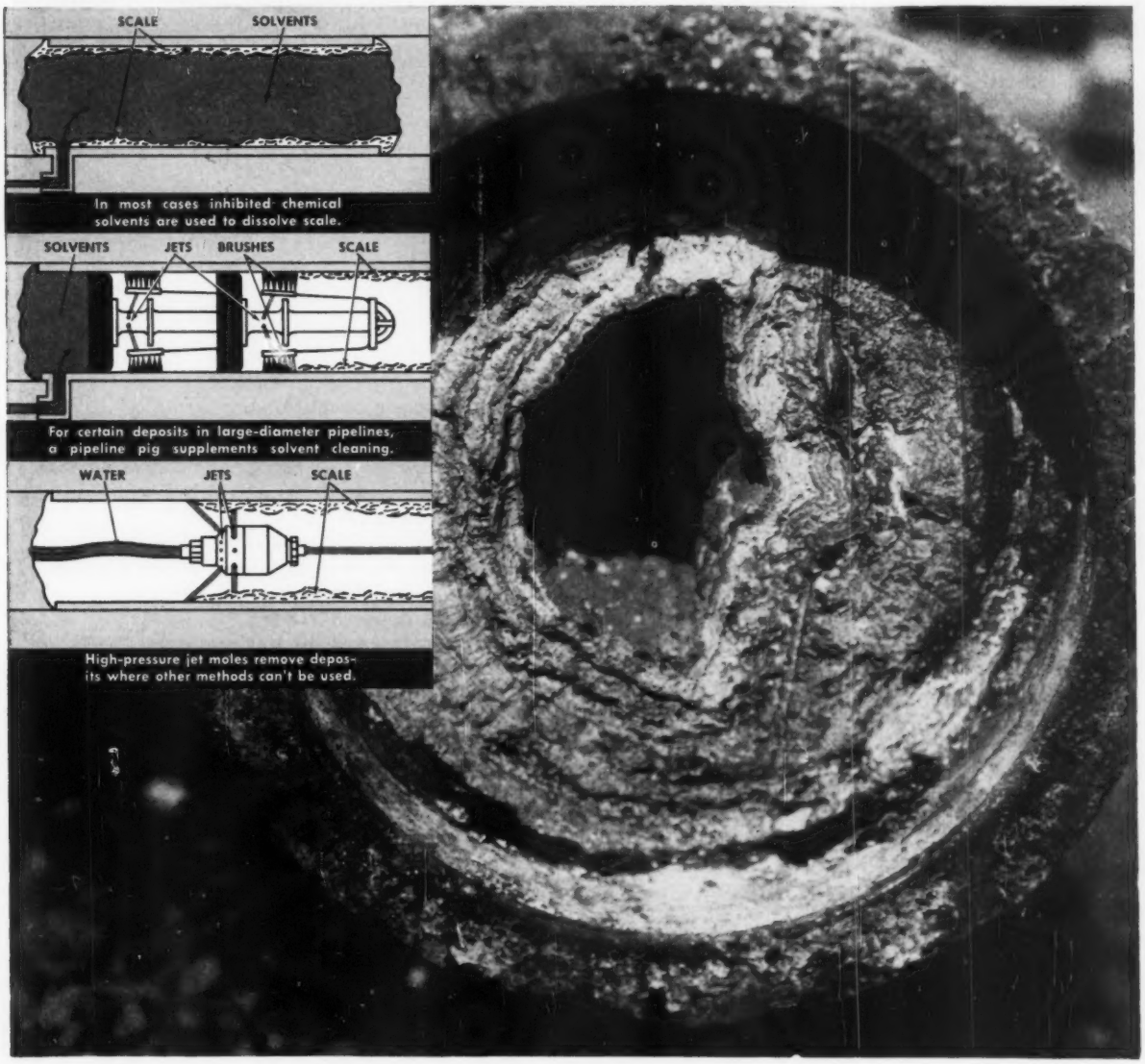
Nation-wide Dow Industrial Service first analyzes the job to be done, then selects the technique which will do the best job, fastest. D.I.S. cleans all kinds of lines—fresh water, boiler feed-water, gas, waste and other lines—and every kind of process and heat exchange equipment.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company. For cleaning *any kind* of equipment, *anywhere* in the U. S., write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW

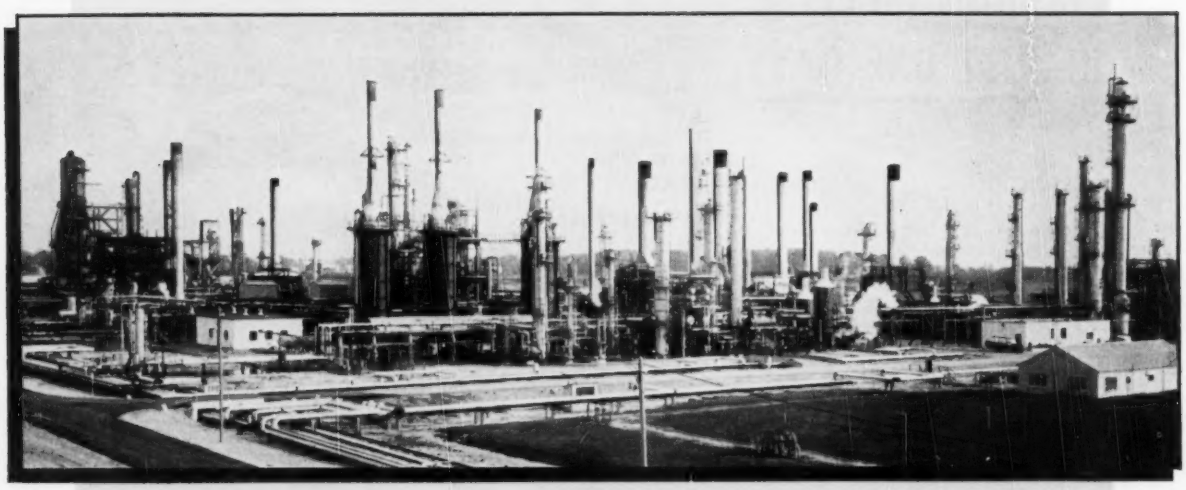
DOW INDUSTRIAL SERVICE • Division of The Dow Chemical Company

From these three methods, D. I. S. selects the one best suited to your specific pipe-cleaning problem.



For more data on advertised products, use Readers' Service Cards, last page.

HOW TO GET MORE OUTPUT FROM YOUR PRESENT PACKED TOWERS



General view of the Sarnia Refinery of Canadian Oil Companies, Limited.

Over the years, U. S. Stoneware, through its continuing research and development program on tower packings and packed tower internals, has gathered much valuable design data. Engineers from industries all over the world contact us regularly for help in designing units for extraction, distillation or gas scrubbing. Very often the problem is "How we can increase the output of a tower now in operation — and can we avoid a long shut-down period doing it?"

Take, for example, Canadian Oil Companies, Limited. Their Gerbitol units in Sarnia, Ontario, were packed with ceramic Raschig Rings. At their last "turn around," they replaced these with Polypropylene Plastic Pall Rings and changed the design of their support plate. As a result, their permissible DEA circulation in this liquid-liquid extraction column was doubled — and may yet be further increased. This was done, moreover, in just the time it takes to change packings.

If you have a problem involving mass transfer operations, pressure drop, capacity, theoretical plates, you'll do well to contact U. S. Stoneware, first.

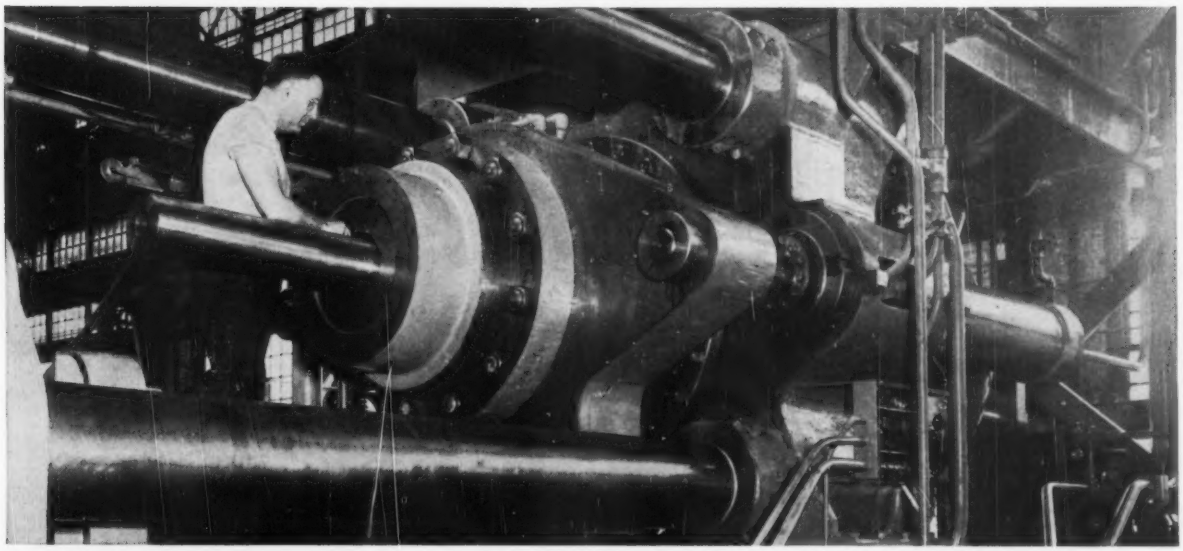
PROCESS EQUIPMENT DIVISION

NEW ENGINEERING MANUAL ON TOWER INTERNALS

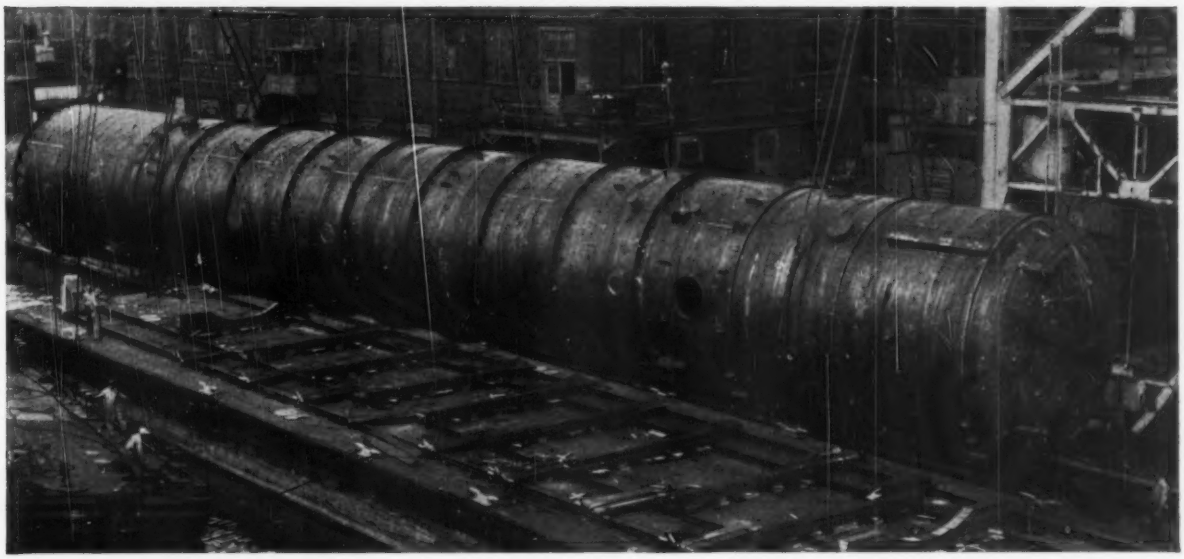
Just off the press, this new 32-page manual gives helpful data on how to select and install proper support plates, distributors and hold-down plates. For your free copy, write Dept. CEP-161.

U. S. STONEWARE
AKRON 9, OHIO

308-G



SUN SHIP has what it takes to build . . . . .



for INDUSTRY

We're old hands at building complete machines and special equipment for use in a wide range of industries. For 44 years our large and amply equipped shops have produced items ranging from small tanks to huge fractionating towers, pressure vessels, stills, plate work and special-purpose machinery for the chemical, petroleum and other industries.

Pictured here are a hydraulic press, which was shipped by rail, and a fractionating tower ready for loading on a barge for shipment by water to an oil refinery. They are just two examples of the equipment Sun Ship contributes to many fields, also examples of our shipping facilities.

Because we have all the facilities, we build all equipment right in our own plant, without subletting. Our convenient location on the Delaware River, with direct access by rail and water to all points, assures speedy delivery.

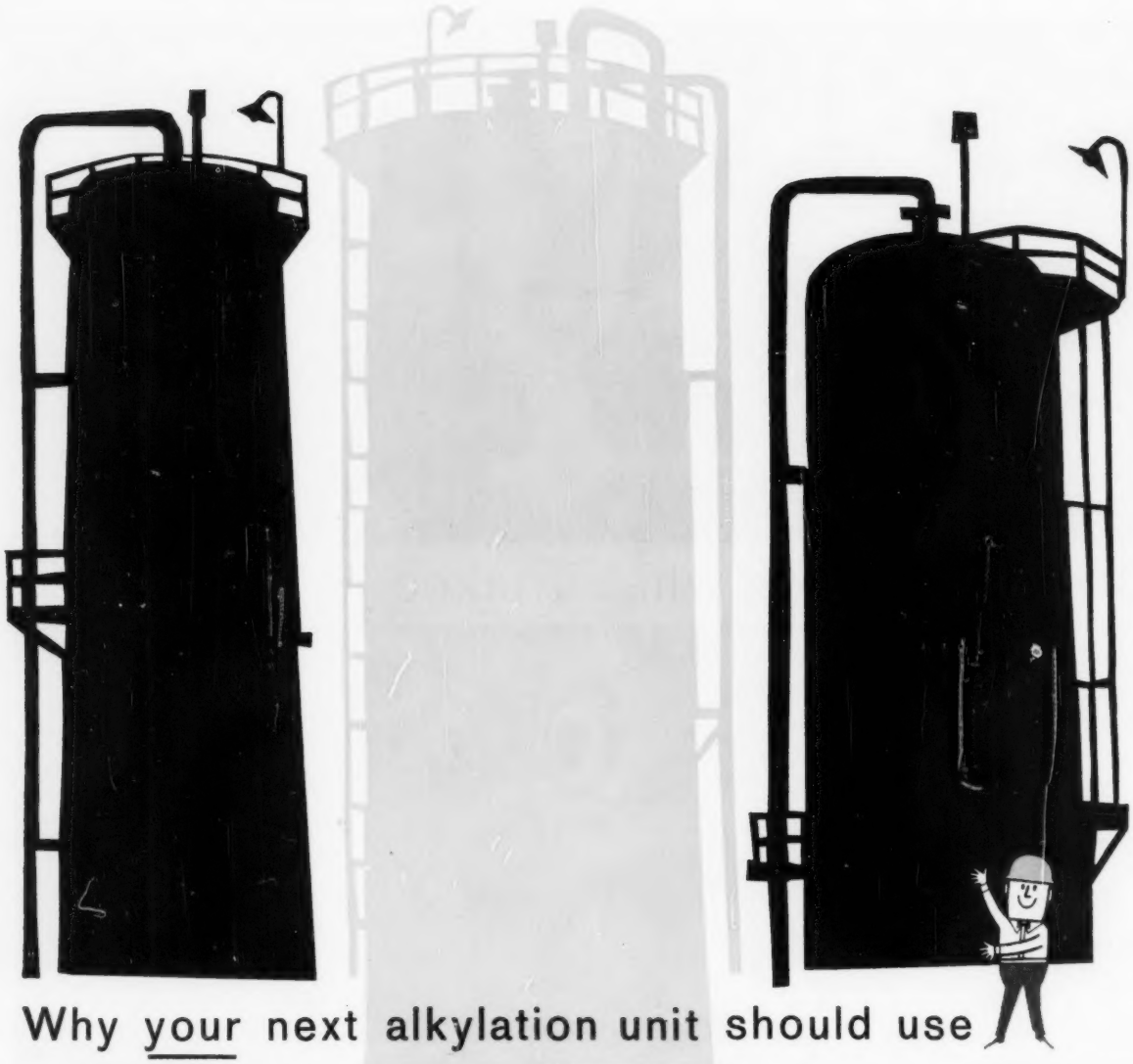
Let Sun Ship solve your machine or equipment problem. Phone or write our Sales Engineering Department.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

For more data on advertised products, use Readers' Service Cards, last page.



Why your next alkylation unit should use

HYDROFLUORIC ACID

Because anhydrous hydrofluoric acid is easily regenerated, you'll consume less catalyst per barrel of alkylate, lower your catalyst inventory and minimize spent acid problems. AHF lets you cool with water, reduces both initial and operating expense for cooling. And in addition to these economies, AHF gives you shorter reaction time and catalyst settling time, with minimum side reaction products. These advantages have been proved in operating alkylation units across the nation.

To help you cash in on AHF, Pennsalt provides expert, experienced technical aid. We'll show you how to handle, store and use AHF safely and economically . . . advise you on piping, pumps, valves and materials of construction . . . help you with employee training programs. See your Pennsalt representative or write for full information. Industrial Chemicals Division, PENNSALT CHEMICALS CORPORATION, Three Penn Center, Philadelphia 2, Pa.

Get this new HF handling and data book. Write for Bulletin S-148.

Pennsalt Chemicals
ESTABLISHED 1850

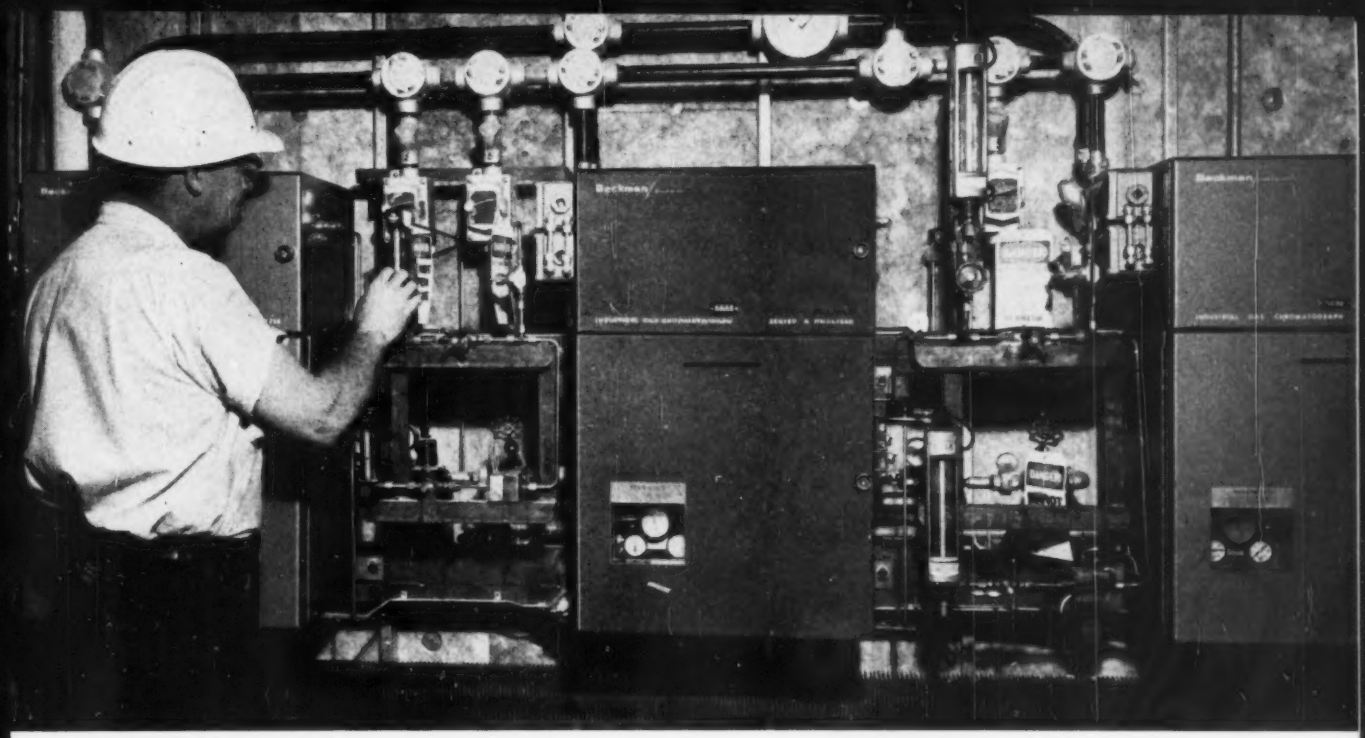
See our complete listing in Chemical Materials Catalog

Industrial Chemicals Division

SALES OFFICES: ATLANTA • CHICAGO • DETROIT • NEW YORK
LOS ANGELES • PITTSBURGH • ST. LOUIS • APPLETON
TACOMA • PORTLAND

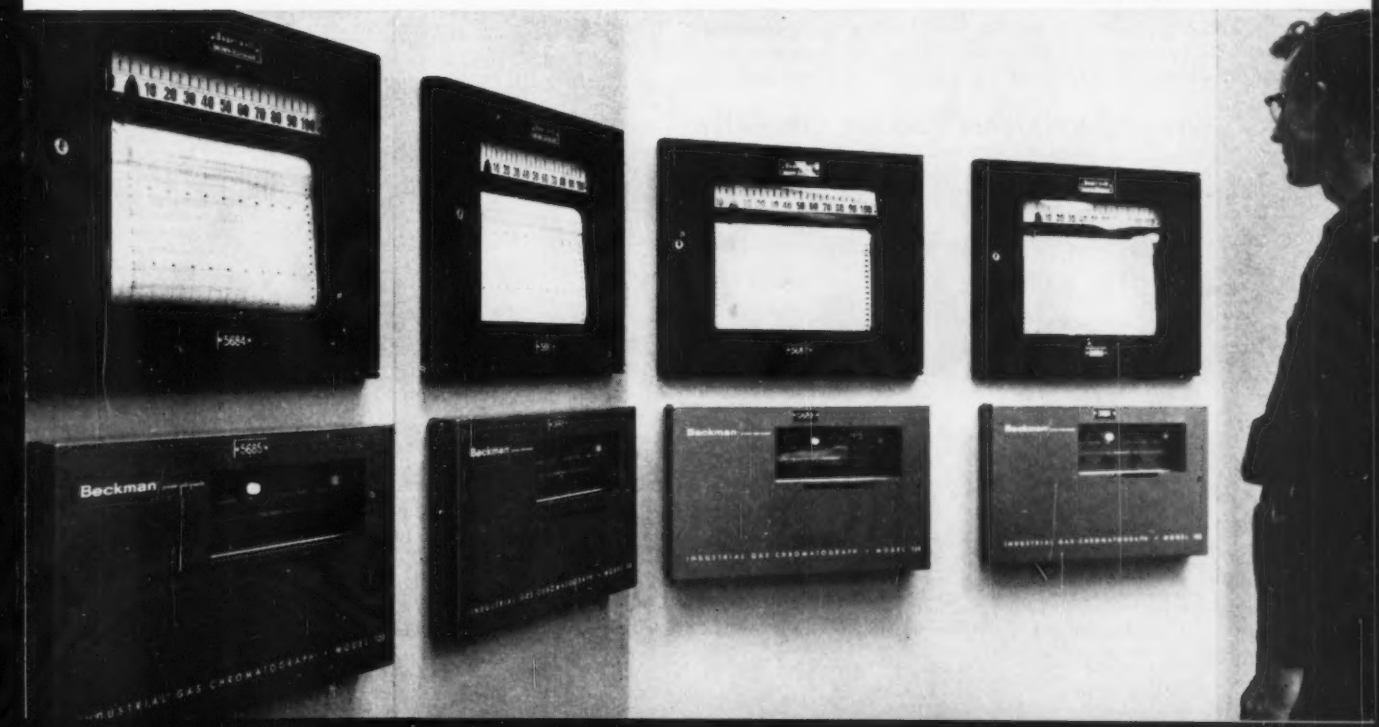
INDUSTRIAL QUÍMICA PENNSALT, MEXICO CITY

For more data on advertised products, use Readers' Service Cards, last page.



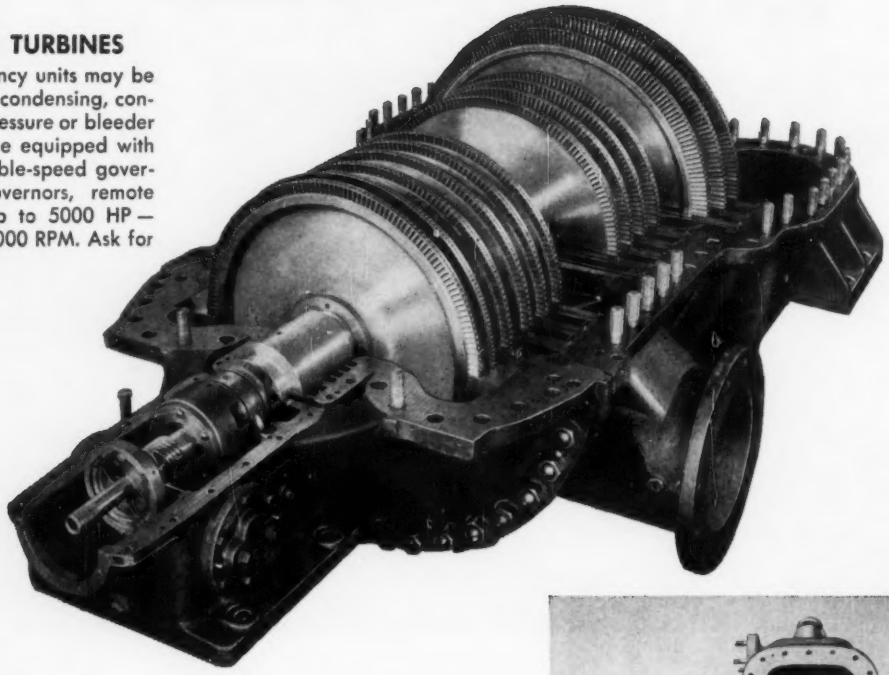
Know-how by Dow... chromatography by Beckman. Beckman gas chromatography analyzers have been making intermediate and end-product analyses of the ethylene process at the Dow Chemical plant, Bay City, Michigan, since 1959. Beckman process chromatographs permit Dow to produce more ethylene, polyethylene, ethyl benzene, and ethyl benzene derivatives at reduced cost and at a consistently high purity level. ⌘ The four Beckman analyzers were chosen by Dow because of their rapid response, efficient analysis performance, reliability of operation, and minimum maintenance requirements. Two are located on distillation towers; another measures the effluent of the catalytic purification unit; the fourth is placed in the ethylene product stream to measure purity of end product. Precise parameter adjustments are made possible by 12 product readings taken from recorders located in a central operations building. ⌘ For more details on Beckman process gas chromatography write for Data File 25-1-07.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
Fullerton, California



MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

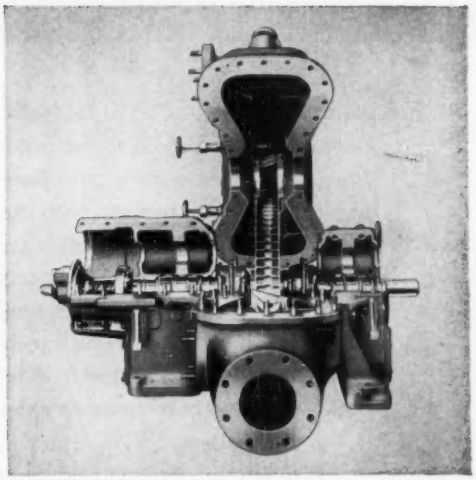
The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

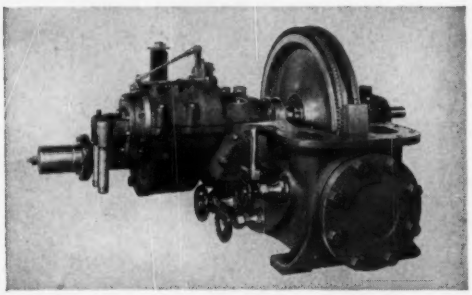
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TERRY



SOLID-WHEEL TURBINES

Famous for sure dependability and ease of inspection. Can be started cold — no preliminary warming required. Available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.



AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.

TT-1209

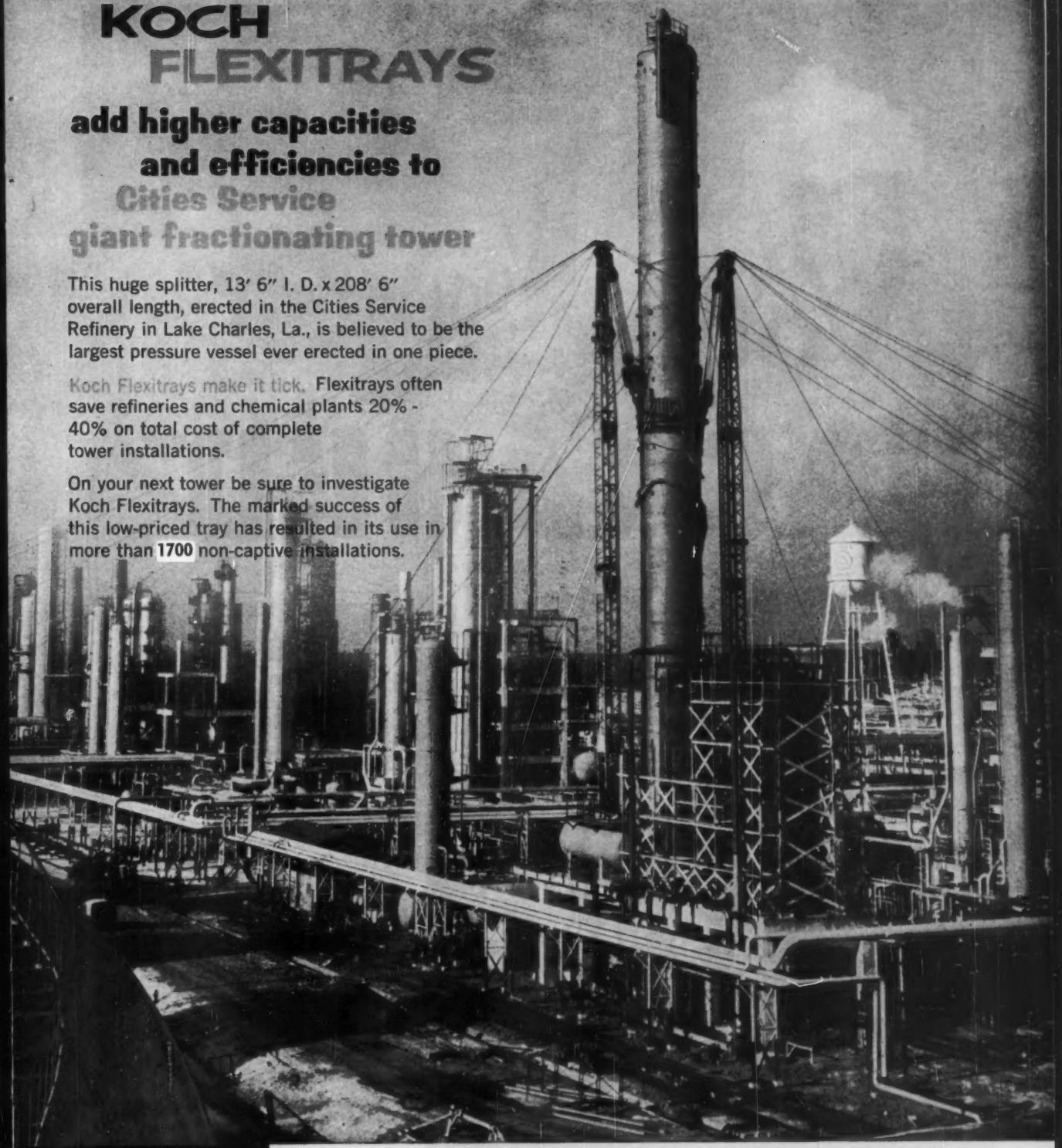
KOCH FLEXITRAYS

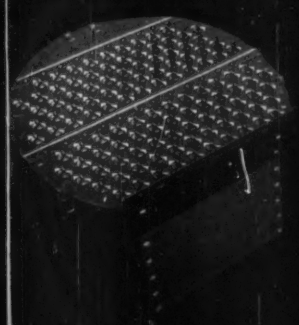
add higher capacities and efficiencies to Cities Service giant fractionating tower

This huge splitter, 13′ 6″ I. D. x 208′ 6″ overall length, erected in the Cities Service Refinery in Lake Charles, La., is believed to be the largest pressure vessel ever erected in one piece.

Koch Flexitrays make it tick. Flexitrays often save refineries and chemical plants 20% - 40% on total cost of complete tower installations.

On your next tower be sure to investigate Koch Flexitrays. The marked success of this low-priced tray has resulted in its use in more than 1700 non-captive installations.





Contact your nearest Koch Representative, or write direct to...

KOCH

ENGINEERING COMPANY, INC.

321 West Douglas Avenue, Wichita 2, Kansas

REPRESENTATIVES

BUTTE, MONTANA — G. M. Wallace & Co., P. O. Box 208
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EL PASO, TEXAS — G. M. Wallace & Co., Suite 511, Electric Bldg.
HOUSTON, TEXAS — Alpha Engineering Co., P. O. Box 12371
KANSAS CITY 13, MO. — Sample Brothers, P. O. Box 7061
NEW YORK 17, N. Y. — F. J. McConnell Co., 60 East 42nd St.
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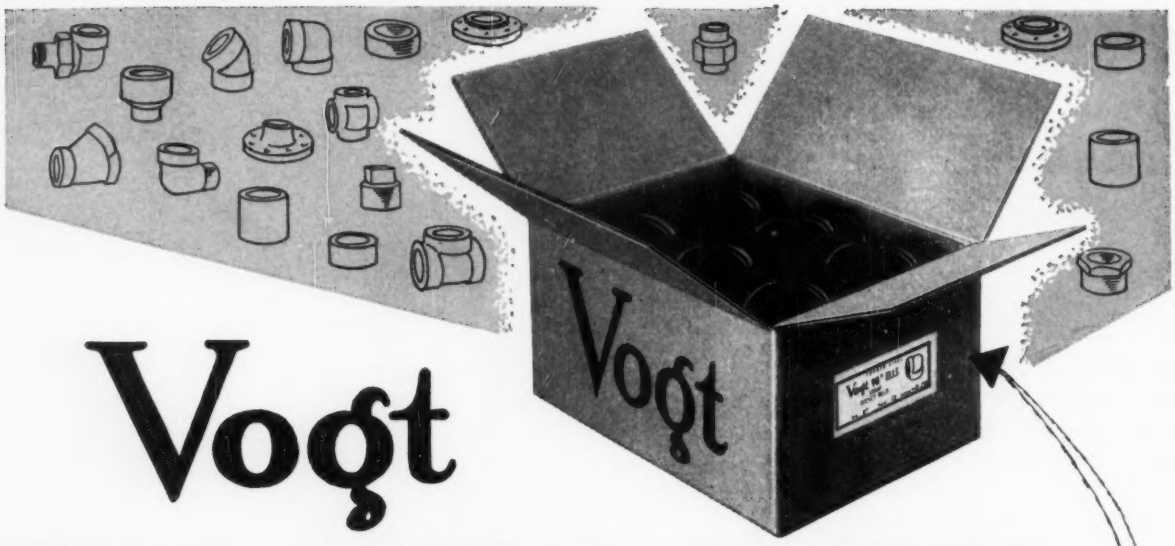
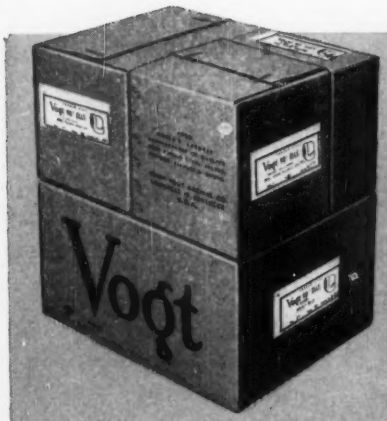
SALT LAKE CITY, UTAH — G. M. Wallace & Co., Continental Bank Bldg.
ST. LOUIS 17, MISSOURI — Sample Brothers, 2010 Big Bend Blvd.
TULSA 18, OKLAHOMA — Myers-Aubrey Co., P. O. Box 5436
SCARBOROUGH, ONTARIO, CANADA — Muirhead Fromson Limited, 65 Hymus Road
FRIBOURG, SWITZERLAND — Koch Flexitrays, S. A., 20 rue St. Pierre
European Fabrication Available!



Vogt PACKAGED

FORGED STEEL FITTINGS, FLANGES and UNIONS

Complete product identification and data on label attached to carton.



Vogt modular designed cartons give added handling and storage space economies. All dimensions are in multiples of 3 inches.

for

MATERIAL HANDLING ECONOMY

1 Easy Inventory Identification

2 Easy Handling

3 Protection Against Damage

Handling and inventory costs are held to a minimum with Vogt modular packaged forged steel fittings, flanges, and unions. The small cartons, of restricted weight, are appreciated by the distributor and user alike for their easy handling and the protection given the products against damage.

The label attached to each carton completely describes and pictures the product and gives the quantity, size, end type, pressure, and catalog number.

Write for Folder PF-1 for complete data on quantities and weights of the items as packaged in various sizes of cartons.

Address Dept. 24A-FPR

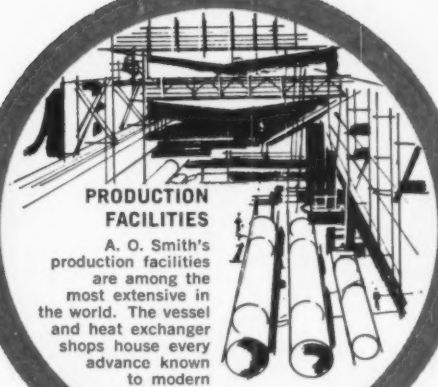
HENRY VOGT MACHINE CO.
P.O. Box 1918, Louisville 1, Ky.

SALES OFFICES New York, Chicago, Cleveland, Dallas, Camden, N.J., St. Louis, Charleston, W.Va., Los Angeles

INTEGRATED specialization

ENGINEERING

MULTI-LAYER construction of high-pressure vessels is just one of A. O. Smith's numerous design innovations. This patented process uses concentric layers of relatively thin steel plate — tightly wrapped and welded around an inner pressure-tight cylinder.

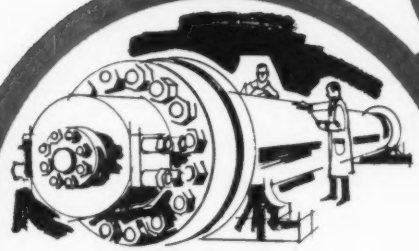


PRODUCTION FACILITIES

A. O. Smith's production facilities are among the most extensive in the world. The vessel and heat exchanger shops house every advance known to modern technology.

WELDING

A. O. Smith is one of the largest production welders in the world. It has pioneered many new concepts for the welding industry.



QUALITY CONTROL

A. O. Smith's high standards for product excellence are a direct result of its ever-expanding test program. Next spring, for example, the world's most powerful metals' inspection x-ray unit will be installed at the Milwaukee plant. The 8-million-volt linear accelerator will "see" through steel more than a foot thick.

RESEARCH

A. O. Smith carries on extensive research in metallurgy, welding, electrical testing, corrosion resistance — to name only a few areas. The company has also become an outstanding contributor in the atomic field.

building block for A. O. Smith leadership in the manufacturing of pressure vessels and heat exchangers

A. O. Smith will build any type, any size of pressure vessel or heat exchanger — *and build it well!* Employing specialists in every phase of its production program, A. O. Smith can guarantee built-in dependability to a wide range of industries from the petroleum and chemicals to the atomic.

A. O. Smith's dedicated staff of research scientists and engineers will help you analyze your process conditions. It will make recommendations as to the design, material and method of fabrication best suited to your particular needs. Write today for specific product information.

Through research ... *a better way*

A.O.Smith
CORPORATION

ATOMIC AND PROCESS EQUIPMENT DIVISION

MILWAUKEE 1, WISCONSIN

For more data on advertised products, use Readers' Service Cards, last page.

A SERVICE THAT ADDS YEARS TO COATING LIFE

This tiny instrument — a film thickness gauge — can mean years more protection for your equipment. It helps find those thin spots in coatings that need extra attention to assure the longest and best possible corrosion resistance. This is just one of the tests conducted by Napko Sales Engineers while rendering follow-through service.

With Napko Industrial Coatings, you get superior formulations that provide heavier protective films in fewer coats, designed to fit your special needs, plus *that one crucial ingredient that doesn't come in the can* — the extra protection of dependable follow-through service by a qualified Sales Engineer.

Whatever, wherever, your corrosion problems may be, there's a Napko Industrial Coating to meet your specifications. Just call or write your nearest Napko Industrial Sales Office.

PROJECT SERVICES OF NAPKO CORPORATION

1. Climatic-Operational Analysis
2. Lab Testing & System Research
3. Field Testing
4. Paint Crew Training
5. Job Inspection in Progress
6. Case History for Repaint

Complete Coating Systems for every Industrial Requirement

NAPKO CORPORATION

INDUSTRIAL COATINGS DIVISION

P. O. BOX 14126 • HOUSTON 21, TEXAS

Save with Solvay's giant, economy-size caustic soda package!

Save two ways when you order caustic soda shipments by Solvay barge. First, barge rates are lower. Second, you save handling . . . with even a small barge you hook up just once to pump out the equivalent of 10 tank cars of caustic soda.

If your plant is located on one of our coastal or inland waterways ask your Solvay representative about cost-saving barge shipments of caustic soda. 50% liquid caustic soda, rayon or regular grade, is available by barge from 3 Solvay producing points . . . Moundsville, W. Va., Brunswick, Ga., and Baton Rouge, La.

SOLVAY® CHEMICALS FOR THE PETROLEUM INDUSTRY

Aluminum Chloride • Carbon Tetrachloride • Calcium Chloride
Caustic Potash • Caustic Soda • Chlorine • Chloroform
Mutual® Chromium Chemicals • Soda Ash • Potassium Carbonate
Sodium Nitrite • Vinyl Chloride Monomer

Allied Chemical

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61 Broadway, New York 6, N. Y.
IN CANADA: Allied Chemical Canada, Ltd.
1450 City Councillors St., Montreal, P.Q., Canada

Branch Sales Offices: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • St. Louis • San Francisco • Syracuse

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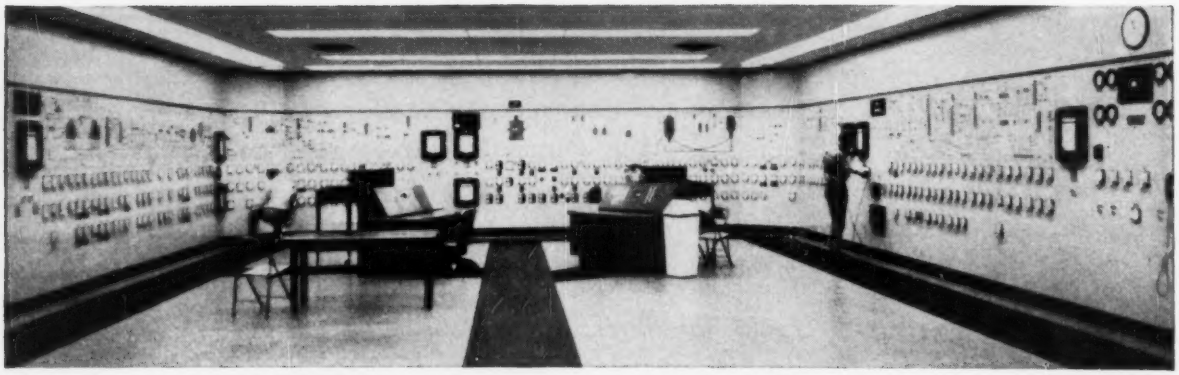
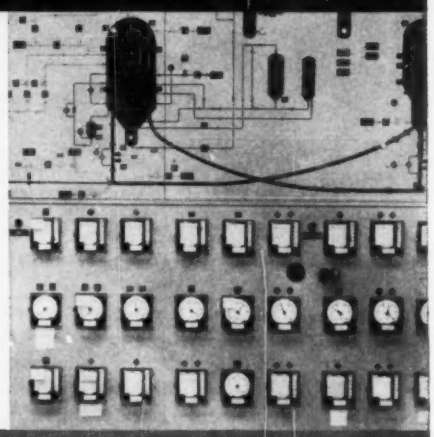


Bristol Metagraphic recorders and indicators occupy lower three rows on panel (shown in two photos above). Enlarged panel section is shown below, right.



"NERVE CENTER" AT BIG NEW TEXACO PLANT INCLUDES BRISTOL METAGRAPHICS

This model central control room is the nerve center for a vast petroleum processing complex. It's located in the new Puget Sound Works of Texaco Inc., at Anacortes, Washington.

A key feature of the control system is a battery of several hundred Bristol Metagraphic pneumatic recorders, indicators, and controllers (lower three instrument rows on panel). The new plant produces motor gasolines, jet fuels, liquified petroleum gases (LPG), diesel fuel, furnace oil, and heavy fuel oil. Crude oil capacity is 45,000 barrels per calendar day. 0.7

This is just one of hundreds of installations of Bristol Metagraphic instruments in use today in processing plants throughout the country. These compact instruments are ideal for graphic panel use, or where true "plug-in" versatility is necessary to insure maximum control system reliability and continuity of service. We'll be glad to send you the complete Metagraphic story. Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

BRISTOL ... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.

Brand-New Sphere of Activity!

Here is a MACROPORT* "A" aluminum oxide sphere — Norton Company's newest development in catalyst carriers shown enlarged. Note its extremely porous structure, specifically designed to promote *faster, more precisely controlled* gaseous reactions. Pores are much larger than those in other Norton catalyst carriers, permitting gases to enter and diffuse readily, yet providing sufficient restriction for optimum control.

MACROPORT "A" catalyst carriers are currently available as spheres, pellets, and aggregate of fused aluminum oxide in the same price ranges as standard Norton carriers. A research program is now underway in the Norton laboratories to develop MACROPORT carriers in other materials.

For better yields from *your* reactors and improved process economy, get complete details on Norton MACROPORT "A" carriers. Write NORTON COMPANY, Refractories Division, 460 New Bond Street, Worcester 6, Massachusetts.

TYPICAL PHYSICAL PROPERTIES

	MACROPORT "A" 5/16"-⅜" Spheres	Aggregate (3-5 Mesh)
Apparent Porosity %	44-48	40-44
H_2O Absorption %	22-26	18-22
App. Sp. Gravity g/cc	3.4-3.6	3.4-3.6
Bulk Density g/cc	1.8-2.0	2.0-2.2
Packing Density lbs./ft³	63-67	68-72
Pore Dia. Range	50-200 Microns	50-200 Microns

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

*Trademark

75 years of . . . **Making better products . . . to make your products better**

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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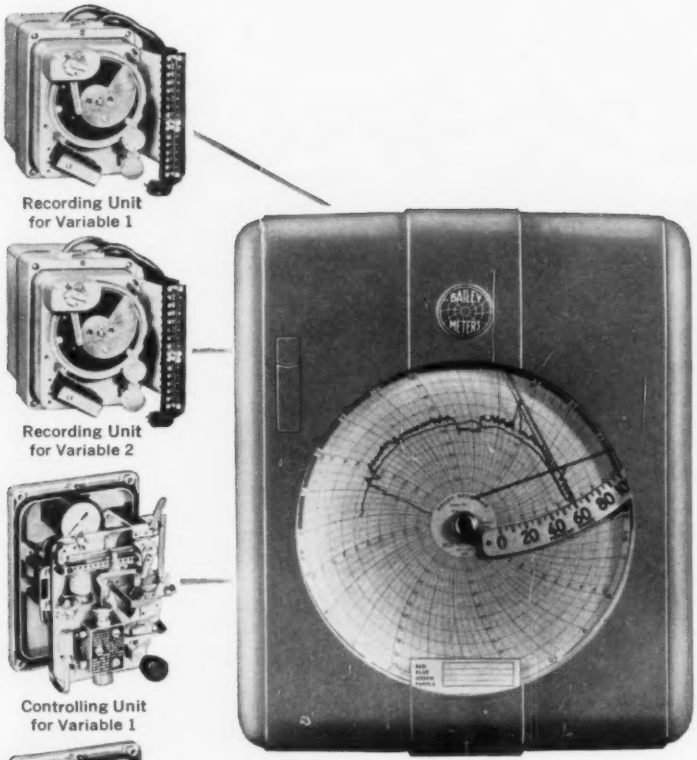
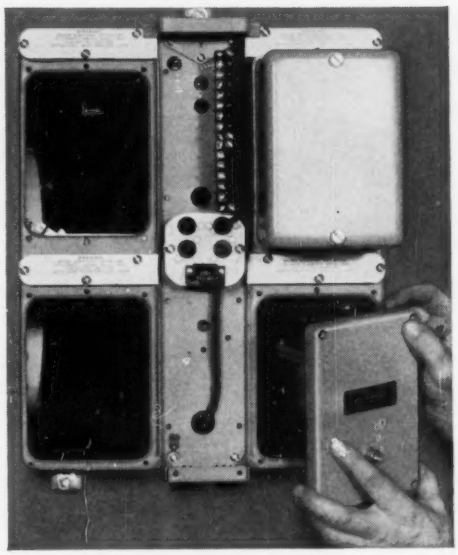

Recording Unit for Variable 1
Recording Unit for Variable 2
Controlling Unit for Variable 1
Controlling Unit for Variable 2

Back of Bailey Recorder, showing how four plug-in units may be added as needed.



Key to "step-by-step" automation . . .

BAILEY RECORDERS

with plug-in flexibility

When you are pioneering a new process and don't know all the answers, complete automation is seldom practical. The first step is to identify your variables and measure them. Nothing does this job better than a Bailey Recorder. One instrument can record any four variables that can be converted to electric *or* pneumatic signals.

Then you will want to add controls and feed back your measurements. Here's where the versatility of the Bailey Recorder comes into play. For the same Bailey instrument you use to record variables is designed to accommodate plug-in control units.

When you use a Bailey Recorder, you can build your instrumentation along with your process. At the start, you use only the plug-in units for recording. Then you add plug-in controls as you see the need for them.

For the complete story of how you can use a Bailey Recorder for step-by-step automation, contact your local Bailey Engineer.

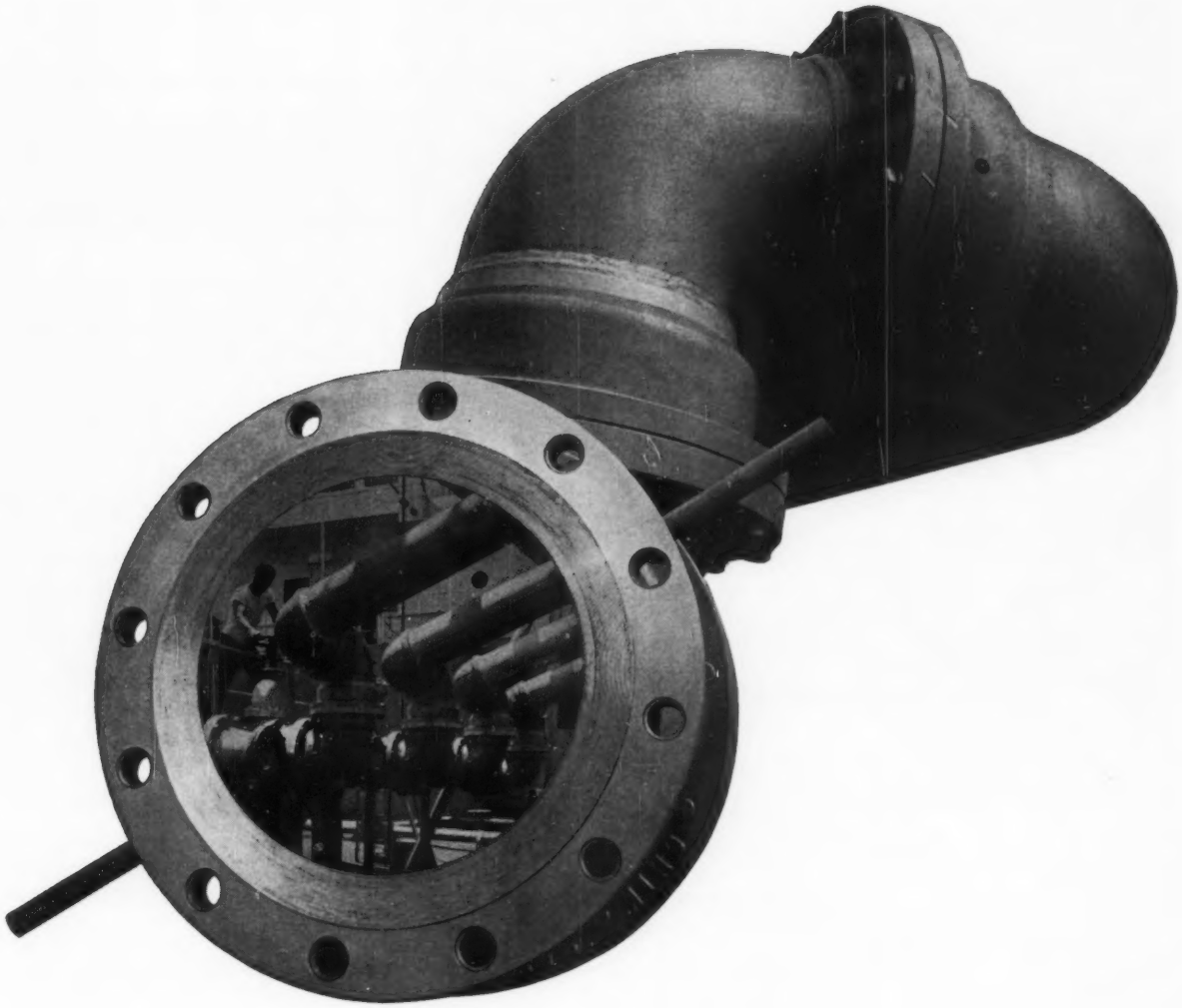
CP111-1

Chemical and petroleum division

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal



THIS IS THE BEST WAY TO LOAD TANKERS-
And the heart of this system is the swivel joint. Produced by a company with 30 years of experience in solving flexible line problems. Proven by hundreds of installations around the world on Chiksan's Hydraulic Marine Loading Systems and other dockside loading lines. Recommended and preferred for safety and long life by responsible men everywhere. It is a **CHIKSAN** Swivel Joint.

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CHIKSAN COMPANY—General Offices: Brea, California • Well Equipment Mfg. Corp. Division (Weco Unions, Hamer Valves) • Chiksan International • Chiksan of Canada Ltd.
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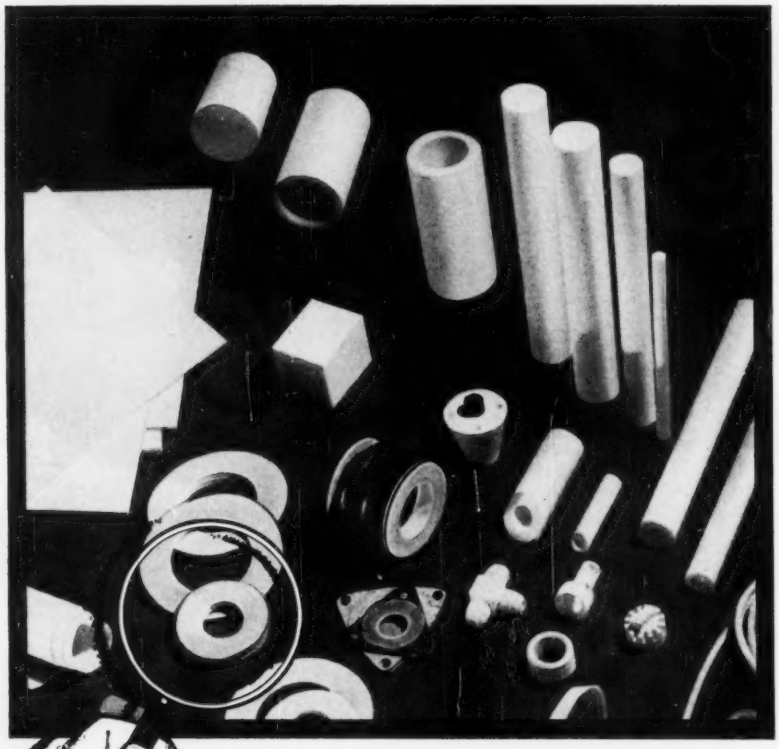
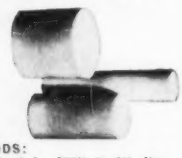
For more data on advertised products, use Readers' Service Cards, last page.



SEARCHING FOR SHAPES OF TEFLON?

Here they are . . . by Doré

SHEETS:
Thickness: 1/32" thru 2"



RODS:
Extruded: .200" to 6" dia.

TUBES:
Molded: 2" O.D. to 30" O.D.
Extruded: ¼" I.D. to 2½" I.D.
½" O.D. to 4" OD..

Sheets, rods, tubes, tape, solid and envelope gaskets, bellows, expansion joints, "O" rings, Vee packing and scores of other shapes of TEFLON* are produced by Doré under the most rigid quality controls. Many exclusive and patented operations are utilized to assure uniform density, freedom of pin holes, dimensional accuracy, and absence of internal stress in TEFLON shapes by Doré. Most of these items are also available in Doré FLUOROGREEN.

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The Mail Box . . .

At Last, We Hope!

To The Editor:

I quite agree with J. A. Kuntze (See The Mail Box, September, 1960, Page 172) that temperature conversion from °C to °F and vice versa is simple but how many mistakes have been made?

We all know that 0 — 100 °C corresponds to 32 — 212 °F and therefore the conversion by multiplying or dividing by 1.8 can be worked out in a split second. But do you add the 32 degrees first or multiply first?

I use the phrase "At (add) last." That is, multiply then add, or subtract first then divide.

Using this phrase I found, without thinking, where Mr. Kuntze was wrong!

L. J. B. Rayburn, British Hydrocarbon Chemicals Ltd., Grangemouth, Scotland

Editor's Note: *Mr. Rayburn is quite right but the fault was ours. Mr. Kuntze's rule should have read:*

Rule: To change °C to °F multiply °C by 1.8 and ADD 32 to the product.

The Whistler Way

The same error (see above) was spotted by R. E. Hodgson, Lago Oil & Transport Co., Aruba who commented:

"This mistake emphasizes the fact that Art Whistler's conversion formula (Page 271, May 1960 PR) is so simple and easy to use. There is no need to remember when to add or subtract. You *always add* 40° F before multiplying (or dividing) by 1.8, and then you *always subtract* 40° F from the product (or quotient). A little mathematical juggling will show that the 'Whistler Formula' is identical to the 'standard' method of conversion. It always gives exactly the correct answer."

Record of An Author

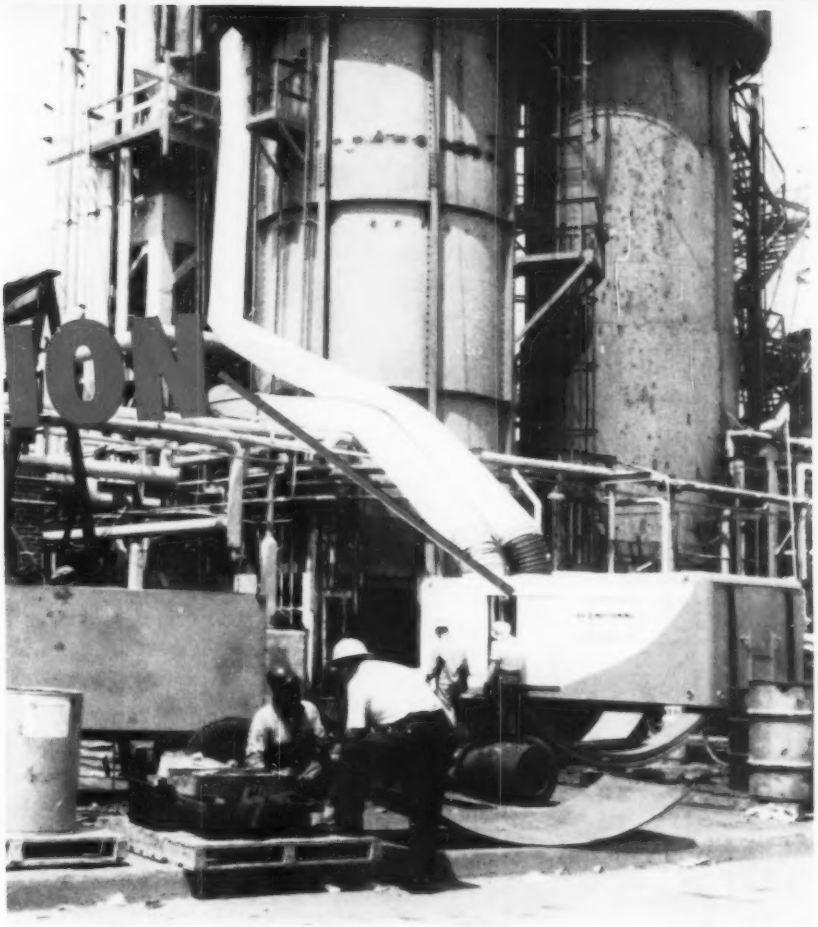
Paul A. Finn's biography (December, 1960 issue, page 158) should have read "Mr. Finn . . . was the assistant to the vice president of engineering and research, Oakite Products, Inc. (1944-1950) and southwestern division manager of sales and engineering, Chemical Research Associates (1950-1954) before joining Wyandotte in his present position."

1961 Petroleum REFINERY MAINTENANCE SPECIAL REPORT

SOLUTION

TO THE PROBLEM OF

Excessive Repair Downtime



IN ANY REFINERY, CHEMICAL OR PETROCHEMICAL PLANT . . . IN ANY HEATER, BOILER OR FURNACE

A Ready Cool 50-ton Air Conditioning unit can be connected to the access doors of any heated vessel and 18,000 C.F.M. air pumped therein until a temperature of as high as 2000 degrees F. is reduced to 600 degrees F.; the air conditioning is then turned on and the temperature further reduced from 600 degrees F. to a workable state.

With the use of a Ready Cool Portable Air Conditioning unit, cooling time is reduced to ⅓ of previous time; in fact, cooling time and normal repairs can be usually completed in the time previously allowed for cooling down only! Similar time savings can be effected *in any heated vessel*, such as: regenerators, boilers, towers, heaters, etc.

For full information about Ready Cool Combination Portable Air Conditioning, Heating and Ventilating Units—Write, Wire or Call

Patent No. 2929223

READY COOL, INC.

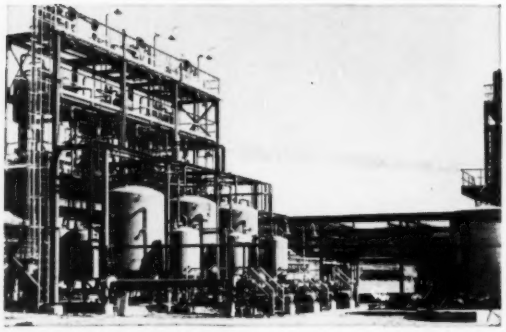
AMERICAN BANK BLDG. NEW ORLEANS, LA.

Why you can be sure...

Celanese Cellulubes are the best functional fluids you can use

There are four practical reasons behind our claim that *you just can't buy better fire-resistant hydraulic fluids or air compressor lubricants than Celanese Cellulubes.*

1



BASIC PRODUCER—Celanese was the *first* to produce phosphate esters . . . and is the *only* producer currently marketing a series of industrial phosphate ester lubricants. Experience has demonstrated that we now have one of the best equipped plants in the country.

2

APPLICATION ENGINEERING—Our files contain facts about hundreds of successful Cellulube applications in many industries. Celanese engineers have the experience and interest to help you make the most of these functional fluids.

3

QUALITY CONTROL—Celanese zealously guards the quality of Cellulubes by a system of constant checks and controls. Physical and chemical properties are strictly maintained within exacting limits to assure you of optimum performance for fire-resistance and lubrication. What's more, Cellulubes have passed the most rigorous tests that the military and some of America's largest companies could devise.

4

TECHNICAL ASSISTANCE—Our technical staff provides assistance to see that the changeover from conventional fluids to Cellulubes is made as quickly and easily as possible. In many cases, our salesmen provide all necessary conversion know-how.

Fire-resistant Cellulubes are available in *six* controlled viscosities. Not only are they outstanding for the prevention of fire and explosion, but they give overall wear protection comparable to premium petroleum oils. Get the complete facts by using the coupon below. Celanese® Cellulube®

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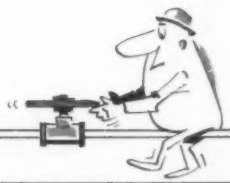
A PETROLEUM REFINER SPECIAL REPORT



Maintenance 1961

PETROLEUM REFINER estimates that the world's refining, petrochemical and gas processing maintenance bill last year was $1,334 million. This includes maintenance materials, equipment and labor. The United States spent approximately $609.4 million of this total.

Breaking this down into figures you can associate with your plant, maintenance cost the average refiner 33 cents per barrel of daily crude capacity. It cost the petrochemical producer about 49 cents per 100 pounds of daily capacity. And it cost the gas processor 39 cents per gallon daily capacity of natural gasoline.

Are these figures high, low or about right when compared with maintenance performance throughout all industry?

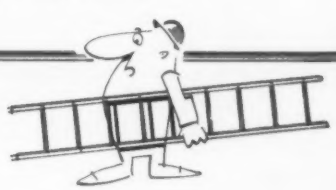
Frankly we doubt if anyone knows the answer to that question because no really good yardstick for comparing costs on an industry-wide basis has been developed. We do know that the loud, clear voice of management today is saying "Hold those costs down."

There doesn't seem to be a magic formula for maintenance cost cutting. It requires a concentrated study of many phases of maintenance department operations. But one thing is pretty well established. Maintenance cost reductions can be made mainly through better maintenance management. Those plants which show a continuous step toward improving their methods of managing the maintenance department also report improved cost reductions.

To that end this special report is dedicated.

Frank Evans

Maintenance & Design Editor



A SPECIAL REPORT
MAINTENANCE

How You Can Start Daily Maintenance Scheduling

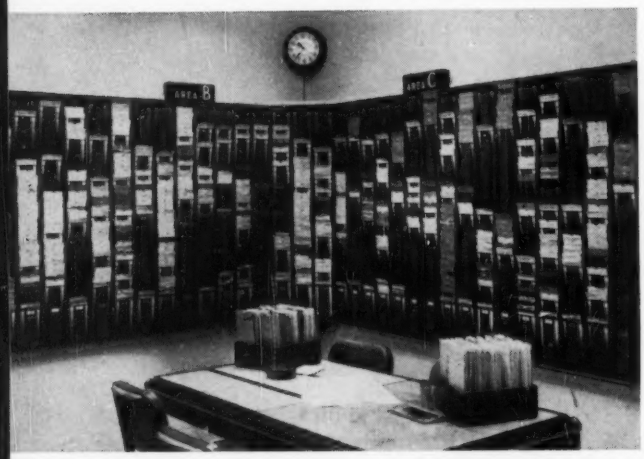


FIGURE 1—Job orders are kept in this specially constructed job order rack.

Purpose of the Job Order Rack

- **Get all the open job orders out of the file cabinets and up on the wall where they may be intelligently evaluated and scheduled.**
- **Permit process assistance in arranging job order priority. This reduces rush orders and at the same time places manpower where it may contribute most to the safe and profitable operation of the refinery.**
- **It assists in daily scheduling. The simple process of moving a job order jacket to the "schedule" portion of the rack permits the rough formation of the schedule.**
- **It provides a complete picture of the Maintenance Department work load in one convenient location.**
- **The equitable distribution of manpower by units is readily apparent as well as excessive backlog of job orders in any one area, unit or activity.**
- **It provides a spacious work area where six men may easily observe or work at any one time.**
- **It permits maximum assistance from the chief scheduler and the clerk.**

Working smarter instead of harder is essential in cutting maintenance costs. Daily scheduling is one step to that goal

John J. Reagan
The Standard Oil Company (Ohio)
Cleveland

"REVERTING to a weekly schedule would be the equivalent of abandoning our welding machines and returning to riveted construction," said the chief scheduler at Sohio's Number 1 refinery in Cleveland one month after the start of daily maintenance scheduling in July, 1958.

The system operates on the idea that the craft foreman should be able to plan the following day's work for his men, after he knows the job priorities. He is the key to a successful daily schedule. His review of the tentative daily schedule should be, by far, the most productive 10 to 15 minutes of his day. It is in this brief period that he allots his manpower to the various jobs to be scheduled, and also makes certain that he has the supporting crafts which are needed to enable his men to accomplish each job in a safe and productive manner.

The system *does not* require that the foremen give up their time as craft supervisors and become schedulers. Quite the contrary, this system of daily scheduling is designed to keep the foreman's schedule-review time to a minimum and cut out a lot of paper work. He gets two sheets of paper. One tells him what to do (the job order) and the other tells him when to do it (the daily schedule, which he helps to assemble.)

CHANGING FROM WEEKLY TO DAILY SCHEDULING

Organization. Daily maintenance scheduling required a total of three additions to the Maintenance Department staff—two area engineers and one scheduling clerk.

Area Engineers. The old system of weekly scheduling used two "coordinators." The division of the refin-

ery between them was on a topographic basis. These coordinators, each supported by a clerk, were spread too thin to do little more than follow the major jobs and transmit job orders and drawings. They originated very few job orders because they were generally written by the process foremen.

Under the new system, four area engineers replace the two coordinators and use the same two clerks originally assigned to the coordinators. The division of the refinery among the four area engineers is on a functional basis and, with minor exceptions, each process foreman need contact only one area engineer for the solution to all his maintenance problems. Area engineers write essentially all but emergency orders; these are still written by the process foremen.

Chief Scheduler. Under the new system of daily maintenance scheduling, the chief scheduler should not be an engineer, but he should be a determined, conscientious individual who can get along with people. The system was designed to eliminate the engineer from scheduling. Eliminating this middleman has a beneficial effect since the area engineer and craft foreman now stand alone in the prosecution of the job.

The present chief scheduler has one full time clerical assistant. This is one of the three new jobs mentioned above. He also requires approximately three hours daily assistance from a secretary.

Equipment for Daily Scheduling. The only new capital equipment acquired to start daily scheduling at the refinery was a photocopy machine costing $300 to reproduce job orders for the craft foremen. An existing ditto machine is used to reproduce the schedule copies required to operate the system.

The job order rack in the schedule office was constructed of 50 special time card racks at a cost of $10.80 each (Figure 1). The installed cost was under $600.

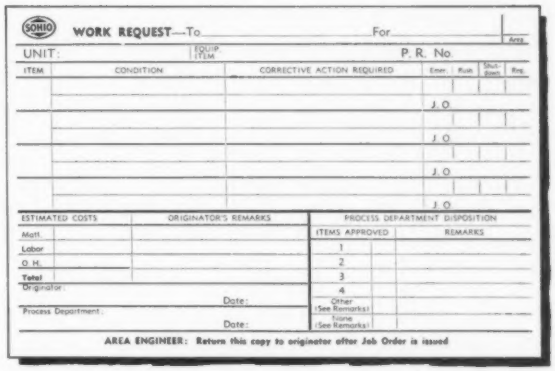
The "paper" required to operate this system, based on an estimated 8,000 job orders, costs approximately $1600 a year. The "paper" for the old system cost approximately $600 a year.

Steps In Daily Scheduling. The focal point of daily scheduling is the schedule office. This office is a medium through which the area engineers communicate with the maintenance foremen about the 100 plus jobs scheduled daily. These contacts, plus the feed-back from the craft foremen are recorded and form the daily schedule.

The information embodied in this schedule represents the combined efforts of four area engineers, fifteen maintenance craft foremen and numerous process foremen.

Step 1. When a process foreman needs some maintenance work completed on his unit he will contact the area engineer who serves his unit. This contact may be verbal or may be written on a pocket sized work request form, see Figure 2. If the job is more than the "repack a pump" variety, it is inspected on the job site by the area engineer in the presence of the process foreman.

Step 2. The area engineer will then write the job order (Figure 3) which will include a brief job description, a listing of the various steps required to complete


SOHIO WORK REQUEST—To For Area

UNIT: EQUIP ITEM P. R. No.

ITEM	CONDITION	CORRECTIVE ACTION REQUIRED	Emer.	Rush	Shut-down	Reg.
			J. O.			
			J. O.			
			J. O.			
			J. O.			

ESTIMATED COSTS	ORIGINATOR'S REMARKS	PROCESS DEPARTMENT DISPOSITION	
Matl.		ITEMS APPROVED	REMARKS
Labor		1	
O. H.		2	
Total		3	
Originator		4	
Process Department	Date:	Other (See Remarks)	
	Date:	Total (See Remarks)	

AREA ENGINEER: Return this copy to originator after Job Order is issued

FIGURE 2—Pocket sized work request forms (4 x 6 inches) are used by the process foremen.

the job (craft sequence), a manpower estimate by craft, special material requirements and safety precautions.

If this is an improvement order, the area engineer will estimate the cost of the job and forward the job order for the general superintendent's approval. Various levels of approval have been determined for other than improvement orders. The upper limit for the process foremen, $300, permits him to approve over 90 percent of the orders written for his unit.

Step 3. When the job order is approved it is forwarded to the schedule office where it is processed and placed in a job order jacket (Figure 4), under the proper unit designation in the job order rack. Photocopies of the job order are issued to all crafts involved on the job.

Step 4. When the area engineer arrives for his daily visit to the schedule office (9:30-10 a.m.), he will arrange the particular job vertically in the job order rack to indicate its relative importance. (The jobs above are more important, the jobs below are less important.) As he moves this job order jacket, he will write on the printed repeating form of the jacket (Figure 4) the manpower he feels should be used on the first day of this job. He will also add any comments that he wants incorporated in the daily schedule adjacent to this job.

Step 5. When the circumstances are such that the men are available to start this job, the job will be entered on the daily schedule form (Figure 5). The foremen review this tentative schedule between 10:45 a.m. and 12:45 p.m. This requires from 3 to 12 minutes per craft and is mainly dependent upon the craft size and number of jobs scheduled. A copy of each job order is readily available for this review. The foremen are free to adjust the number of men and hours for their crafts and add additional crafts or equipment if needed on the day scheduled. In this way the foreman is definitely a part of daily scheduling and by setting the number of men, he maintains his foreman's responsibility of determining job method.

Step 6. After the foremen's review of the tentative daily schedule, it is checked by the chief scheduler, retyped on the daily work schedule form and published. The schedule is in the hands of the process and mechanical foremen by 2:30 p.m. daily. Job priority is indicated by the item number of the job on the schedule. (The major job priorities for the week are determined by the

Refinery Operations Committee). An overlay method has been developed for reviewing the jobs which cannot be completed on the day scheduled. This overlay solved a timing problem for the schedule office and also prevents dropping a job before the foremen indicate the job is complete.

OVERLAY

This is the key to daily efficient scheduling. It would not be possible to use this scheduling plan easily without the overlay system. It was developed in two days (and two sleepless nights) after daily scheduling started in Standard of Ohio's Number 1 refinery in July 1958.

What Is Overlay? It is a system of reviewing the jobs on today's schedule by the craft foremen and the chief scheduler to see if they should be continued on tomorrow's schedule. It is called overlay because part of a blank daily schedule is stapled over today's schedule.

What Does It Do? It allows the foremen to make quick estimates of the work to be done *tomorrow* and provides an easy means for the scheduler to gather this information. The daily schedule must be published on time if the system is to function well. The overlay system is a means of simplifying the mechanics of getting the schedule out on time.

How Does It Work? Figure 6 shows part of today's Maintenance Department daily work schedule with the overlay sheet directly below it. A job will be entered on the overlay portion of tomorrow's tentative schedule only if the job is included on today's schedule. After stapling the overlay to the work schedule, as shown in Figure 7, slash marks are made on each craft block in which manpower was scheduled for *today.*

After the job order was published on today's schedule (this was done yesterday) the schedule clerk marks the item number of the job as it appeared on today's schedule in the same block of the jacket's repeating form. He then returns the job order jacket to the rack.

Area Engineer. When the area enginner arrives at the schedule office *today,* he marks the job order jacket with the manpower desired for tomorrow's schedule in a new block. For example, from Figure 4, Item 33 (today's schedule, July 14), the area engineer fills in a new block for tomorrow as follows: carpenters 3/3 - rmv. scaf."

Chief Scheduler. When the chief scheduler removes this jacket from the rack, he glances at the previous block and notes that the job was scheduled as Item 33 on today's schedule. He then goes directly to Item 33 on the overlay portion of tomorrow's daily schedule and writes in 3/3 under the carpenter column and the comment, "rmv. scaf." He will cross out the existing comments, "*reins & **instl. chain wheel." Figure 8 is an example of the area engineer's manpower estimates entered on the overlay by the chief scheduler.

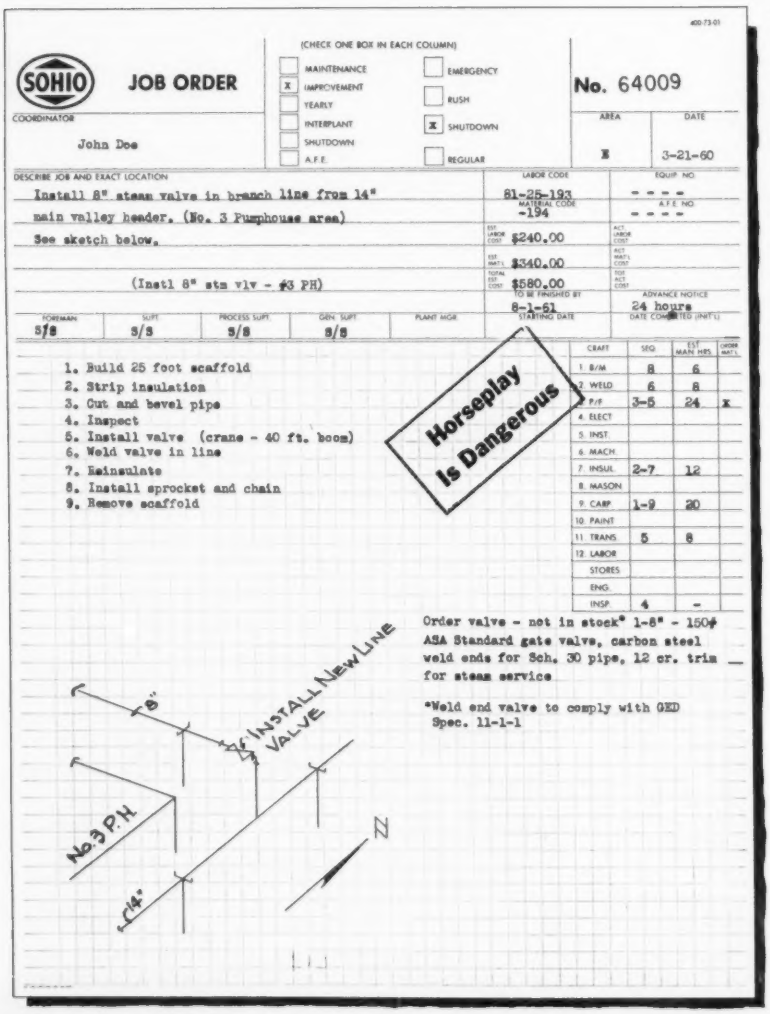

SOHIO
JOB ORDER
No. 64009
John Doe
Install 8" steam valve in branch line from 14" main valley header. (No. 3 Pumphouse area)
See sketch below.
(Instl 8" stm vlv - #3 PH)
$240.00
$340.00
$580.00
8-1-61
24 hours
1. Build 25 foot scaffold
2. Strip insulation
3. Cut and bevel pipe
4. Inspect
5. Install valve (crane - 40 ft. boom)
6. Weld valve in line
7. Reinsulate
8. Install sprocket and chain
9. Remove scaffold
Horseplay Is Dangerous
Order valve - not in stock* 1-8" - 150# ASA Standard gate valve, carbon steel weld ends for Sch. 30 pipe, 12 cr. trim for steam service
*Weld end valve to comply with GED Spec. 11-1-1
INSTALL NEW LINE VALVE
8"
No.3 P.H.
14"
N

FIGURE 3—The job order is normally hand written by the area engineer.

Things to Note About Figure 8.

1. On Item 42, no manpower estimate was made. This indicates that the area engineer feels that the job will be completed today.

2. No time estimate was shown for pipe fitters in Item 45 because these condensers will not be ready for blank pulling tomorrow.

3. No time was indicated for the automotive or labor shops for Item 46 since they should finish today. The pipe fitters and boilermakers were indicated to plate and pull blanks. Note also that the comments

Purpose of the Job Order Jacket

- **It holds a copy of the job order and possibly a copy of requisitions.**
- **It forms a "package" which may be easily moved in the rack to set priorities and form the daily schedule.**
- **The transparent rear window will show enough of the job order to refresh the memory of the area engineer, craft foremen and chief scheduler on the scope of the job.**
- **The top 1 1/16 inch of the jacket front, which will be exposed in the rack shows: Job number and area, brief job description, requested completion date (if given), three adjacent check blocks to indicate status of special material (material required, material requisitoned, and material received), dual purpose check block to indicate if prefabrication is required and if completed, crafts involved, and craft sequence.**
- **The remainder of the job order jacket contains a repeating form which will assist the chief scheduler in preparing the daily schedule.**
- **The jacket forms a complete history of when the job was scheduled.**

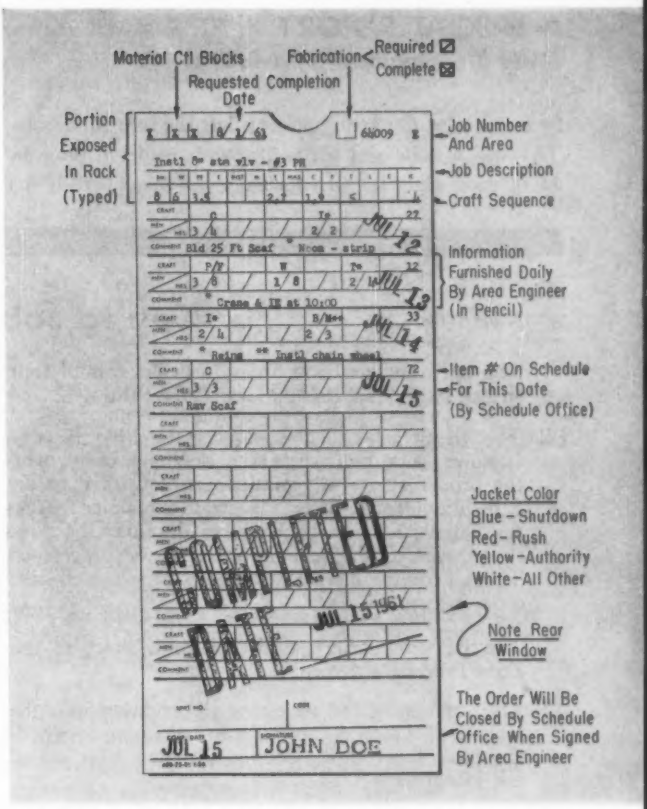


FIGURE 4—This side of the job order jacket gives the progress of the work. The job order itself may be seen through the rear window of the jacket's other side. (See next page "Key to Job Order Flow" between key numbers 5 and 6).

on this item are different from Figure 7. These are new comments taken from the job order jacket.

Foremen. When the foremen review the schedule between 10:45 a.m. and 12:30 a.m., they make comments on the overlay in red pencil (Figure 9). Because the foremen arrive after the area engineer's 9:30 a.m. visit, they are able to put information on the schedule which was not available to the area engineer.

Things To Note About Figure 9.

1. All of the craft foremen changed the slash into an F in Item 42 which indicates to the chief scheduler that this job order will be finished today and should not appear on tomorrow's schedule. This concurs with the area engineer.
2. Item No. 44—The boiler shop foreman indicates by marking an F over the 2/4 that he will finish this job today and no time will be required on tomorrow's schedule.
3. Item No. 45—The boiler shop foreman has informed the chief scheduler that gasket surface repairs were found necessary after removing the condenser channel. Together, they add laborers for sand blasting and welders for building up the surface prior to machining. The chief scheduler then notes this information on the job order and has photocopies of the job order issued to the three additional crafts required. This is information which was not available earlier when the area engineer made his estimates. (Information of this nature is accepted by the schedule office, by phone, right up until the schedule is run off. Sometimes a supplement to the daily schedule must be published. The supplement consists of jobs, usually rush orders, called in by the area engineers before 3:45 p.m. (quitting time is 4 p.m.). This supplement may consist of new orders or last minute changes to tomorrow's schedule. It is only delivered to the craft and process foremen directly concerned. We average three supplements per week and two and one-half jobs per supplement.

Figure 10 shows the job orders which the foremen indicated were completed, lined out by the chief scheduler. After the schedule is published, the chief scheduler marks F in pencil on the rear of the jacket and returns it to the rack in the reverse position. It is then up to the area engineer to, (1) initial the jacket as complete and place it in a closed order tray in the schedule office, or (2) if he is not certain that the job is complete, he will leave the order open and check the job in the field. As far as the schedule office is concerned, the area engineer opens and closes each job order.

The overlay accomplishes the following:

- *It solves a timing problem.* For the first two days of daily scheduling, we wrote out the tentative schedule

by hand after the area engineers left the schedule office. This was a mess and we had to rush to get it done by 11:00 a.m. when the first foreman was scheduled. Using the overlay, we were finished by 10:30 a.m. and were able to move the foremen's review to 10:45 a.m. This also gave the chief scheduler time to digest the tentative schedule.

• *The overlay prevents dropping a job from the schedule before the foreman indicates that it is finished.* The overlay, through the slash mark, asks the foreman

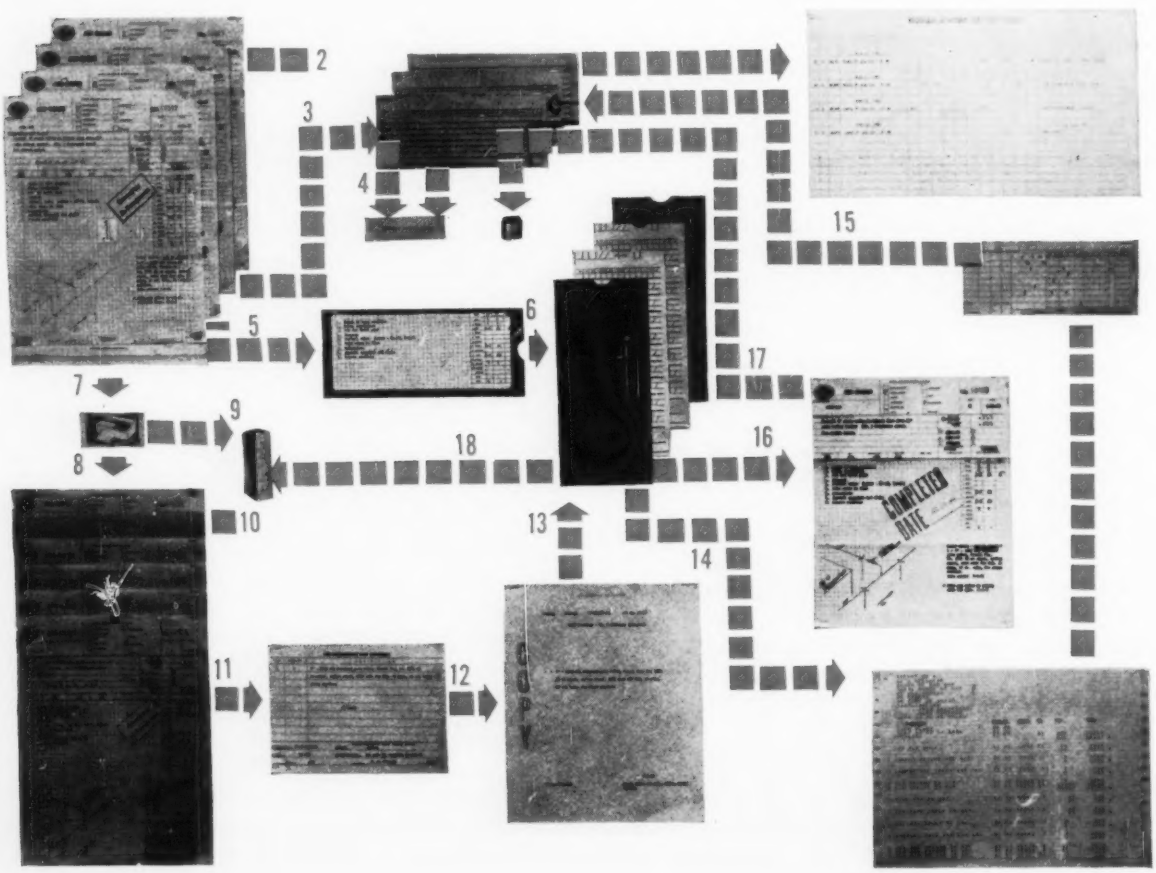
Key to Job Order Flow

1. The pre-numbered job order form consists of four sheets; two white, one pink, and one yellow.
2. The yellow job order sheet is retained by the area engineer. The two white and one pink sheet, with the proper approval signatures, is forwarded to the Schedule Office. After the chief scheduler checks the job order for scope, code etc., he turns the three sheets over to the scheduling clerk for processing. The scheduling clerk logs the job order in the job order registered.
3. The scheduling clerk sends the pink sheet to the Data Processing Office.
4. After punching the necessary information into the labor and material cards, Data Processing forwards the pink sheet to the process foreman who signed the job order.
5. The first white job order sheet (the original) is then folded by the scheduling clerk and inserted in the job order jacket.

   The jacket color indicates the type of job:

   Blue—Shutdown
   Pink—Rush
   Yellow—AFE—(Authority For Expenditure)
   White—All Other
6. The job order jacket heading is typed in by the scheduling clerk and he then places the jacket in the job order rack.

   The job order rack is divided by areas and subdivided by units or activities. There are three vertical divisions within each unit or activity. The upper division consists of job orders which are currently being scheduled. The center division (regular for schedule purposes) consists of job orders



where he stands and if he agrees with the area engineer that his manpower is not required for tomorrow's schedule for this job. If he is finished with this job, he will change the slash mark to an F. If he is as far as he can go until another craft finishes its work, he will put a horizontal line through the slash mark. He can also drop the job if an unforeseen material problem developes by writing *"Material"* adjacent to his craft block. If the foreman realizes he will not finish the job today, he will enter his manpower estimate for tomorrow.

• *It feeds the overlay portion of the tentative schedule back to the foreman in the same order as he is working on today's schedule.* This permits a quicker recall of the job status. Some foremen actually use their copy of to-

which are awaiting scheduling. This division may include shutdown orders which require prefabrication. The bottom division consists of shutdown orders. All job order jackets within the regular and shutdown divisions are kept arranged vertically, by priority, by the combined efforts of the process foreman and the area engineer.

7. The second white job order sheet (the carbon) is used for reproduction purposes in the photo-copying machine. One copy is made for each craft indicated on the job order.
8. The reproduced job order copies are immediately sent to the craft foreman indicated on the job order. **There is no holding file in the scheduling office.**
9. After being used for reproduction, the second white job order sheet is filed numerically within the scheduling office. This file is used for future maintenance performance studies.
10. Pink photo-copy paper is used for rush orders, buff for all others.
11. Special material required for the job will be pre-requisitioned by the craft foreman who will use the material. The exception is on AFE's where the Engineering Department will issue a bill of material.)
12. After the pre-requisition is approved by the appropriate general foreman, and the maintenance superintendent it is forwarded to the Storehouse.
13. After typing the requisition, the refinery purchase clerk sends one copy of the requisition to the Scheduling Office. Note that the job order number is on the requisition. The scheduling clerk checks the material requisitioned block on the job order jacket and "file" the requisition in the jacket with the second white job order sheet. A second copy will be sent to the craft foreman who wrote the pre-requisition.
14. The craft sequence and man/hours suggested daily on the job order jacket by the area engineers will be hand lettered on a rough copy of the daily schedule by the scheduling clerk. After approval by the craft foreman, the final copy of the daily schedule will be typed on the preprinted (ditto) daily schedule form, run off and issued.
15. Labor and material cards for the scheduled jobs are sent to the Data Processing Office.
16. When the area engineer indicates on the job order jacket that a job order is closed, the scheduling clerk will close out the job order in the job order register.
17. The scheduling clerk then stamps the jacket copy of the job order with the "completed" stamp and sends it to the Data Processing Office.
18. The job order jacket is filed for future maintenance studies.
19. Upon receipt of the stamped second white job order sheet, Data Processing punches the orange master card to clear the labor and material card from the system.
20. Data Processing issues 30 plus reports from data accumulated through the medium of the job order number. These reports assist all levels of management.
21. This card, containing the complete labor and material charges is sent to the unit foreman.

- Get all the open job orders out of the file cabinets and up on the wall where they may be intelligently evaluated and scheduled.
- Permit Process assistance in arranging job order priority. This reduces rush orders and at the same time places manpower where it may contribute most to the safe and profitable operation of the refinery.
- It assists in daily scheduling. The simple process of moving a job order jacket to the "schedule" portion of the rack permits the rough formation of the schedule.
- It provides a complete picture of the Maintenance Department work load in one convenient location.
- The equitable distribution of manpower by units is readily apparent as well as excessive backlogs of job orders in any one area, unit or activity.
- It provides a spacious work area where six men may easily observe or work at any one time.
- It permits maximum assistance from the chief scheduler and the clerk.
- It holds a copy of the job order and possibly a copy of requisitions.
- It forms a "package" which may be easily moved in the rack to set priorities and form the daily schedule.
- The transparent rear window will show enough of the job order to refresh the memory of the area engineer, craft foremen and chief scheduler on the scope of the job.
- The top 1 1/16 inch of the jacket front, which will be exposed in the rack, shows the following:
  1. Job number and area
  2. Brief job description
  3. Requested completion date (if given)
  4. Three adjacent check blocks to indicate status of special material (material required, material requisitioned, and material received)
  5. Dual purpose check block to indicate if prefabrication is required and if completed.
  6. Crafts involved
  7. Craft sequence
- The remainder of the job order jacket contains a repeating form which will assist the chief scheduler in preparing the daily schedule.
- Colored jackets are used to assist in scheduling. The jacket colors are as follows:

  Pink—Rush
  Blue—Shutdown
  Yellow—AFE (Authority For Expenditure)
  White—All others

- The jacket forms a complete history of when the job was scheduled

MAINTENANCE DEPARTMENT DAILY WORK SCHEDULE

DATE PAGE OF

PRIORITY NO.	AREA	JOB NO.	JOB DESCRIPTION (INCLUDES LOCATION)	B/M	WELD	P/F	ELEC.	INST.	MACH.	INSUL.	MASON	CARP	AUTO	LABOR	COMMENTS
			July 12, 1961												
27	E	64009	Instl 8" Stm Vlv - #3 PH							2/2*		3/4			Bld 25 Ft Scaf *Noon - Strip
			July 13, 1961												
12	E	64009	Instl 8" Stm Vlv - #3 PH		1/8	3/8							2/4*		*Crane and IE at 10:00
			July 14, 1961												
33	E	64009	Instl 8" Stm Vlv - #3 PH	2/3						2/4					Instl Chain Wheel - Reins
			July 15, 1961												
72	E	64009	Instl 8" Stm Vlv - #3 PH									3/3			Rmv Scaf

Note: Job order 64009 will normally appear on the daily schedule for four (4) successive days. The information contained in this schedule is suggested by the Area Engineers (see job order jacket) and approved by the Craft Foremen. This approval occurs between 10:45 A.M and 12:45 P.M. while the foremen review the rough draft of the next day's schedule. The approved schedule is then typed on the preprinted daily schedule ditto, run off and issued.

100-74-01 3-59

UNLESS INDICATED OTHERWISE, ALL RUSH & MULTICRAFT JOBS WILL START AT 7:30

2/8 = 2 MEN WILL WORK 8 HOURS EACH

FIGURE 5—Daily schedule form shows how job order (Figure 3), jacket (Figure 4) and daily schedule tie together.

day's schedule in this portion of the review. They have the names of their men assigned to the job noted on the schedule. Some have the manpower and supporting crafts they will need noted. (The schedule office is like a sponge drawing information from all contacts).

The typed job number, job description and comments on the overlay are easier to read during the review, are easier to type after the review and eliminate most transposition type errors.

TENTATIVE DAILY SCHEDULE

The tentative daily schedule is composed of the following:

- New rush orders
- The overlay
- New "must" orders
- New "if possible" orders

New Rush Orders. Most of these are hand carried to the schedule office by the area engineers at 9:30 a.m. They are processed immediately, (jacketed etc.), and listed in pencil on a separate blank schedule sheet. The photocopies of these orders are handed to the foremen during the schedule review.

The Overlay. This consists of jobs which must be continued from today's schedule.

New "Must" Orders. These are jobs which the area engineers *must* get started. They indicate this to the chief scheduler by the position of the jacket in the rack. This listing is written out on a separate blank schedule sheet.

New "If Possible" Jobs. These are jobs which may be started if the chief scheduler needs additional work for the crafts involved. After the manpower on the rush, must, and overlay is tallied, but before the foremen's review, enough "If Possible" jobs are removed from the "If Possible" section of the job order rack to raise the manpower schedule in each craft to approximately 120 percent, the "If Possible" jobs are listed on a separate blank schedule sheet.

After the foremen's review, the chief scheduler num-

PRIORITY NO	AREA	JOB NO	JOB DESCRIPTION	B/M	WELD	P/F	AUTO	LABOR	COMMENTS
42	C	2237	Chg #2 Rctr - Poly	5/2*		2/2*	1/2*	7/5	2nd Day *Trk 7:30 **2:00PM ***7:30 &2:00
43	A	4864	Rpl Hot Well - # 1 CU	3/8	1/8				Shop Prefab
44	A	4827	Rpr Stairway 181 Tk	2/8					Repl Approx 30 Treads
45	D	6018	Cln Ovhd Conds - Ckr	6/8*		3/2*			*Blk & 30 **Open 10:30 P/R &2/9 - 2:0
46	B	5330	Cln 67 Tk - AsP				1/2*	10/8	*Dumpster On Call

FIGURE 6—Part of today's schedule is shown with the overlay below.

bers the schedule for tomorrow. The procedure is as follows:

1. Number the new rush orders and pass them to the schedule clerk to start typing.
2. Line out the completed jobs on the overlay.
3. Continue the numbering with the rush orders still open on the overlay.
4. Continue the numbering through the Operations Committee Priorities on the overlay.
5. Continue the numbering through the "must job" sheet.
6. Go back and finish numbering the overlay.
7. Take a quick check on the scheduled manpower by craft, and continue the numbering through the "If Possible" sheet until the manpower requirements are fulfilled. (Multicraft "If Possible" jobs cannot be scheduled near the end of the schedule because of our policy which is to over-schedule approximately 20 percent. A multicraft job must be scheduled high enough to assure that all needed crafts will be available. The mechanics of scheduling dictate that the last page or two of the schedule be single craft jobs. This becomes routine for the chief scheduler.)

PRIORITY NO	AREA	JOB NO	JOB DESCRIPTION	B/M	WELD	P/F	LABOR AUTO		COMMENTS
42	C	2237	Chg #2 Rctr - Poly	/		/	/	/	2nd Day *Trk 7:30 **2:00PM ***7:30 &2:00
43	A	4864	Rpl Hot Well - # 1 CU	3/8	1/8				Shop Prefab
44	A	4827	Rpr Stairway 181 Tk	2/4					Repl Approx 30 Treads
45	D	6018	Cln Ovhd Conds - Ckr	3/8		/			*Blk 8:30 **Open 10:30 P/R 8219 - 20
46	B	5330	Cln 67 Tk - AsP	2/4		3/4	/	/	*Plt - AM **Pull Blks - PM

FIGURE 7—The overlay is stapled in place and slash marks are made in blocks where manpower was scheduled for today.

PRIORITY NO	AREA	JOB NO	JOB DESCRIPTION	B/M	WELD	P/F	LABOR AUTO		COMMENTS
42	C	2237	Chg #2 Rctr - Poly	/		/	/	/	2nd Day *Trk 7:30 **2:00PM ***7:30 &2:00
43	A	4864	Rpl Hot Well - # 1 CU	/	/				Shop Prefab
44	A	4827	Rpr Stairway 181 Tk	/					Repl Approx 30 Treads
45	D	6018	Cln Ovhd Conds - Ckr	/		/			*Blk 8:30 **Open 10:30 P/R 8219 - 20
46	B	5330	Cln 67 Tk - AsP				/	/	*Dumpster On Call

FIGURE 8—The chief scheduler enters the area engineer's estimate of craft manpower required tomorrow for each job.

PRIORITY NO	AREA	JOB NO	JOB DESCRIPTION	B/M	WELD	P/F	LABOR AUTO		COMMENTS
42	C	2237	Chg #2 Rctr - Poly	/		/	/	/	2nd Day *Trk 7:30 **2:00PM ***7:30 &2:00
43	A	4864	Rpl Hot Well - # 1 CU	3/8	1/8				Shop Prefab
44	A	4827	Rpr Stairway 181 Tk	2/4					Repl Approx 30 Treads
45	D	6018	Cln Ovhd Conds - Ckr	3/8		/	2/4		*Sandblast O.S. - AM **Deposit Weld - PM
46	B	5330	Cln 67 Tk - AsP	2/4		3/4	/	/	*Plt - AM **Pull Blks - PM

FIGURE 9—The foremen's review of the overlay takes place after the area engineer's visit and their comments (shown in color) complete the information needed to schedule the job.

PRIORITY NO	AREA	JOB NO	JOB DESCRIPTION	B/M	WELD	P/F	LABOR AUTO		COMMENTS
~~42~~	~~C~~	~~2237~~	~~Chg #2 Rctr - Poly~~						~~2nd Day *Trk 7:30 **2:00PM ***7:30 &2:00~~
43	A	4864	Rpl Hot Well - # 1 CU						Shop Prefab
~~44~~	~~A~~	~~4827~~	~~Rpr Stairway 181 Tk~~						~~Repl Approx 30 Treads~~
45	D	6018	Cln Ovhd Conds - Ckr						
46	B	5330	Cln 67 Tk - AsP						

FIGURE 10—Because the foremen said jobs 42 and 44 were complete, they were lined out on the schedule.

FINAL DAILY SCHEDULE

The schedule format is as follows:

Routine Jobs. These are jobs of a routine nature which are entered on the schedule by the schedule clerk after receiving the initial instructions from the area engineer.

An example: Every second Tuesday a machinist is scheduled four hours to take vibration readings on the major items of rotating equipment.

This routine section of the schedule will eventually develop into a formal preventive maintenance program. At present an average of seven routine jobs are scheduled daily.

Rush Jobs. A rush job is a scheduled job. (Note: These are not emergency jobs. They are handled immediately and are not scheduled.) Upon receipt in the schedule office, a rush order will be placed on the next schedule published. Every effort will be made to start on this job at 7:30 a.m., the day scheduled. The most efficient sized crews and combination of crafts will work this job during the regular 7:30 a.m.- 4:00 p.m. day. Overtime is not authorized. The job will continue to be scheduled in the rush classification until complete. The insulation and scaffold removal portion of most rush jobs are dropped to the "if possible" portion of the schedule. At present, 10 rush jobs are scheduled (average) daily.

Regular Jobs. These are all jobs on the schedule below the routine and rush jobs. Presently the average is 88 regular jobs daily. An attempt is made to over-schedule approximately 20 percent in each craft. This is necessary since some process equipment will not be available as scheduled and some jobs will be completed sooner than anticipated.

If a job is of such a nature that it will require more than one day to complete, the entire cycle within the schedule office will be repeated. At 9:30 a.m. the area engineer will indicate on the repeating form of the job order jacket what additional manpower or crafts are required for the following day. This is transferred to the tentative schedule and reviewed by the maintenance craft foreman (between 10:45 and 12:45). The reviewed schedule is then published by 2:30 p.m.

Yearly Orders are written to cover minor preventive maintenance type repairs on each unit, (example—inspect and repair steam traps) and are also used to cover major repetitive jobs such as changing clay filters and recharging Poly reactors (Figure 11). A jacket, marked yearly orders, and crayoned green, is filled with inserts

listing all yearly orders for the unit. This jacket is placed at the bottom of each unit rack. An additional jacket is used, where applicable, to hold major repetitive job inserts.

If a process foreman has a particular steam trap which has been giving him trouble and he did not wish to wait for the steam trap men to catch it on their regular rounds, he would tell his area engineer. The area engineer would pull an insert from the jacket, check the job order number, indicate the craft and manhours required, and note the location of the trap. He would then place the insert sheet in the "must" portion of the rack and the chief scheduler would treat it as he would a jacketed order. When the area engineer is satisfied the job is completed, this particular insert is destroyed but the yearly job order remains open.

A major repetitive job on which the timing is quite certain is ideal for a yearly order. The order itself spells out in detail how the job is to be done and a backed photocopy of the order is given to each foreman involved for his permanent file. When the process foreman tells the area engineer that a particular clay filter must be changed, he need only pull an insert, put the number of the clay filter on it and place it in the must section of the rack. This takes about 10 seconds of the area engineer's time, the schedule office does the rest.

One order on a job of this nature (approx. 70 clay filter changes per year) eliminats a mass of repetitive paper work and permits the machine accumulation of year-to-date costs.

Incidentally, the Item 42 on Figure 6 is a yearly order, (Job Order No. 2337—charge No. 2 reactor—Poly.). All the area engineer did to activate this order was to indicate the number of the reactor and checkmark if he wanted the normal 1st and 2nd day scheduling arrangement.

CLAY FILTER — YEARLY ORDER — CHANGE ◆

Job No.	Job Description
2506	Chng # ____Clay Fltr
2506	Chng # ____Excelso Fltr
2507	Chng # ____Filter Screen

	B/M	P/F	Auto	Lab	(Comments)
Filters 3,4,5,6	2/4	2/4	1/2 •	5/6	Requires Rocco Truck • Dumpster on call
Filters 1, & 2	2/4	2/4	1/4 •	5/6	• Dumpster-haul clay

No. 28

FIGURE 11—Yearly orders are repetitive covering such jobs as changing clay filters.

PRE-REQUISITION FOR MATERIAL

ITEM	QUANTITY	DESCRIPTION
1	1	8" - 150# ASA Standard gate valve Powell Fig. No. 1503 WE or equal, carbon steel weld ends for Sch. 30 Pipe, 12 Cr. trim, for steam service.

J. O. #04009

RECEIVED
JUNE-28

ACCOUNT CHARGEABLE 81-25-250-01 USE OF MATERIAL Block valve for main valley steam system

DATE NEEDED 7-1-61 JUSTIFICATION OF DATE NEEDED J. O. completion date 8-1-61

APPROVED BY s/s ORDERED BY P. H. O'Toole DATE 3-27-61

M 220 12-54

FIGURE 12—The pre-requisition is used by the craft foreman to order material.

MISCELLANEOUS ITEMS

Material. Since material availability is of prime importance in scheduling, special material requirements are followed by the scheduling office. This is done as follows:

- When the area engineer indicates on the job order that special material is required, the schedule clerk checks the "material required" block on the job order jacket.
- When the craft foreman orders this material, he places the job order number on the pre-requisition (Figure 12). The storehouse returns a carbon copy of the requisition to the foreman, and also sends a carbon copy to the schedule office. The schedule clerk checks the "material requisitioned" block on the job order jacket and "files" the requisition in the job order jacket.
- When the material is received, the storehouse notifies the schedule office, the schedule clerk checks the "material received" block on the job order jacket, and the job order is scheduled.

A Familiarization Program was conducted in the schedule office before and shortly after the start of daily scheduling. During this period, over 100 people were introduced to this new system.

Safety. An additional safety contact is made with our craftsmen by stamping safety reminders on the job orders before reproduction (Figure 3). The men carry these reminders to the job site.

Abbreviations. We developed a listing of abbreviations to conserve space on the daily schedule and for data processing reports. The spaces available for the job description in data processing (only 26) and the need for a meaningful description on these reports was a major reason for abbreviations.

Typical of the abbreviations used are: "abs" for absorber, "assm" for assemble, "tsb" for tar separator bottoms, etc.

ADVANTAGES DAILY VS WEEKLY SCHEDULING

- The daily schedule has greater flexibility. The weekly work schedule was published every Thursday and listed the major jobs to be worked on the following week. An unplanned shutdown of a major unit after Thursday could result in working for an entire week without a formal work schedule. A daily schedule permits rapid recovery from unforescen events of this nature.
- The process foreman is relieved of most of his mechanical problems and can devote more of his time to improving operations on his unit. This is the result of the area engineers writing all but emergency orders and following the progress of the jobs in the field. As an additional bonus, when the job orders are written by men familiar with the Maintenance Department they are written in such a manner that they will be of maximum use to the craft foremen and the craftsmen in the field.
- More jobs can be scheduled. The number of jobs scheduled increased from an average of 23 jobs weekly to an average of 105 jobs daily.
- We now have a system for following the material status of each job requiring special material.
- The number of men required for unscheduleable work has decreased by 71 percent, (from 49 to 14). The percentage of emergency work is now only 4.4 percent of total manhours.
- The craft sequence, crew size and job priority are indicated on the daily schedule. This is supplemented by any comments which might assist the crafts.
- The number of open job orders decreased from over 1500 in May 1958 to less than 500 active orders in November 1958. This was possible because the area engineers had closer contact with the job and the system made deadwood awkward to deal with.

HOW TO IMPROVE DAILY SCHEDULING

By the Area Engineers?

- Include more information on job orders. Some examples:
  a. Estimate scaffold height
  b. Give line size (Pipe)
  c. Include equipment PR (property record) number (a tag on each piece of equipment)
  d. Include a rough sketch of the job location—in most cases this need only be an X near a tank, tower, building, and a North arrow.
- Write more comments on the job order jackets for incorporation into the daily schedule.
- Write the job orders as far in advance of the schedule date as possible.
- Give the Carpenter Shop more lead time for scaffold construction. Check the job in the field before indicating on the jacket that the scaffold should be removed.

By the Maintenance Foreman?

- Make sure that the supporting crafts needed by your men are indicated on the tentative schedule. If not, add them!
- Check non-routine jobs in the field before the schedule date. (This, of course, will not be possible with Rush Jobs.) If the job order is not clear, check with the area engineer.
- Plan and pin down on the schedule the timing of crane lifts and the usage of other automotive equipment. Requesting a crane for the entire day and using it for several lifts, which could have been made in one hour with no inconvenience to your craft, is poor planning. This also prevents the scheduling of other jobs requiring a crane.
- Write out the Pre-Requisition for material as soon as possible after the receipt of the job order. Be sure the job order number is noted on the Pre-Requisition.
- Arrive at the scheduling office at the assigned time so that no congestion will occur.

By the Process Foreman?

- Have the equipment scheduled for maintenance work available as scheduled.
- Give the area engineer as much lead time as possible in planning repairs.
- Check the job orders which you sign to be certain that the work indicated as "Shutdown" cannot be accomplished during regular operations. This will reduce the length of shutdowns.
- Check the job orders you sign to be certain that the work indicated as other than "Shutdown" can be accomplished without a shutdown. This will prevent scheduling a job and then calling it off when it is determined on the unit that it cannot be done without a shutdown. This is a waste of maintenance manpower.

##

"Few things demoralize employees as much as to sit around waiting for work while management fumbles—no matter how much they pretend to themselves that they enjoy their paid rest. Few things constitute such conclusive proof of management's incompetence in their eyes. To schedule so that there is always work to do for the man is not a minor matter."

About the Author

John J. Reagan is a process engineer at The Standard Oil Company (Ohio), Number 1 refinery in Cleveland. His work now principally deals with utilities (fuel efficiency activties). Prior to his present position, he was an inspection engineer and the planning and scheduling engineer in the Number 1 refinery. Mr. Reagan holds a Bachelor of Mechanical Engineering degree from Rensselaer Polytechnic Institute (1951) and a Master of Science in Engineering Administration degree from the Case Institute of Technology (1959). He is a registered professional engineer in the State of Ohio.

Reagan

A SPECIAL REPORT

MAINTENANCE

Shop Tester Checks Pneumatic Tools

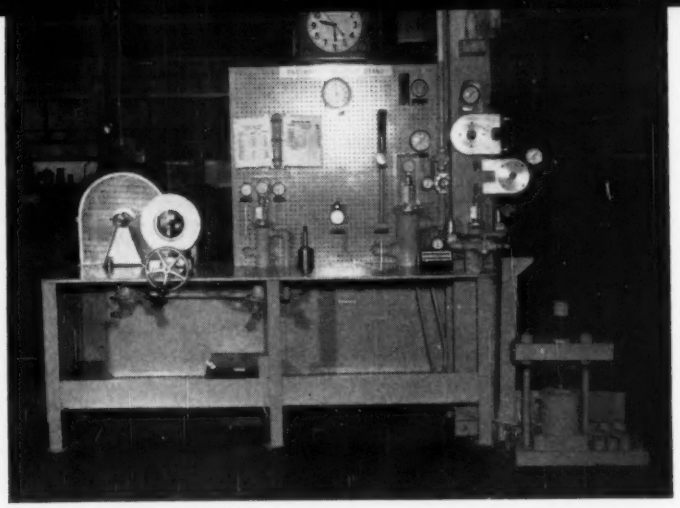


FIGURE 1—This is the test stand developed to check tool performance.

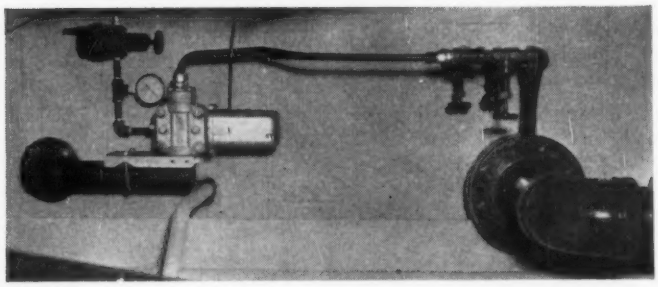


FIGURE 2—Orifice plate and transmitter check sump pump capacity.

- *Tests save maintenance manhours by checking for tool defects before job is started*
- *Tests provide reliable method for comparing tools being considered for purchase*
- *By simulating plant field conditions, testing checks manufacturer's claim of quality*

Ray M. Kolb and Ralph H. Lange
Standard Oil Co. (Indiana)
Whiting, Ind.

ARE YOU POSITIVE that your repaired pneumatic tools are operating at maximum efficiency? You can be if you accurately test each tool on a test stand developed in the Tool Repair section of the Whiting Refinery of the Standard Oil Company (Indiana). It is used to check operating efficiency of sump pumps, impact wrenches, air drills, percussion tools and other miscellaneous speciality items.

Tools found to have a low standard of performance after repairs are not sent back to the job, thereby saving manhours which might otherwise have been wasted in using defective or inadequate tools. In addition, the test stand provides a reliable and accurate method for the selection of pneumatic tools being considered for purchase. By simulating certain field conditions, it can be used to check manufacturer's claims regarding tool quality.

It is also practical to use the stand for testing tools other than the pneumatic type, such as ratchet wrenches. These can be given a torque test to determine whether they can withstand severe strains developed under working conditions.

The Test Stand in Figure 1 is used to establish minimum standards of performance which each repaired tool must meet before it is put back in service. It is designed with the controls and regulators within easy reach of the operator and the gages and flow meters are mounted for ready viewing. Data on tool standards are enclosed in plastic and mounted in book form for quick reference. Space is provided at the bottom of the stand for accessories and equipment used in the various tests.

TOOL TESTING

Sump Pump Tester. The sump pump tester measures the pump capacity in gallons per minute against an adjustable discharge pressure. Water is pumped from a sump through a throttling valve and an orifice plate and returned to the sump. The pressure drop created by the orifice plate is measured by a differential pressure transmitter which can be read on the instrument board. Fig-

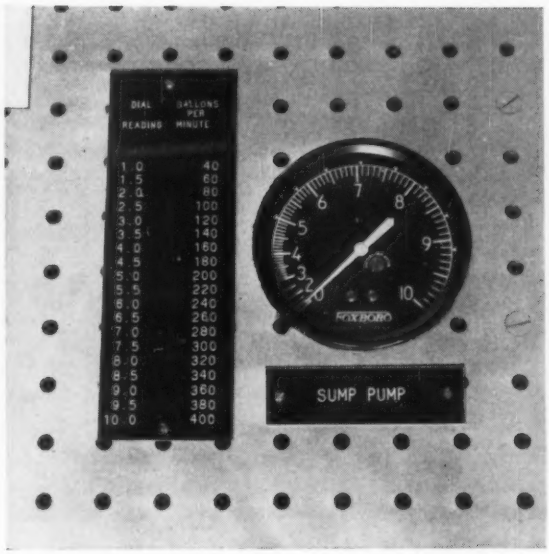


FIGURE 3—Table mounted on panel converts gage reading to gallons per minute.

FIGURE 4—Repairman connects slip joint to section of hose for sump pump test.

ure 2 shows both the orifice plate and the transmitter. The reading on the gage, shown in Figure 3, is converted into gallons per minute by the use of the conversion table mounted to the side.

The pump's discharge nozzle is connected to the slip joint of the manifold with the short section of water hose as shown in Figure 4 and the air hose is attached to the pump which takes suction directly from the sump reservoir. The repairman moves to the test stand, opens the air supply valve slowly, adjusts the air pressure regulator according to the standard for the tool and notes the capacity reading. The repairman is shown opening the air valve in Figure 5. The air consumption of the tool is measured during operation by means of an orifice

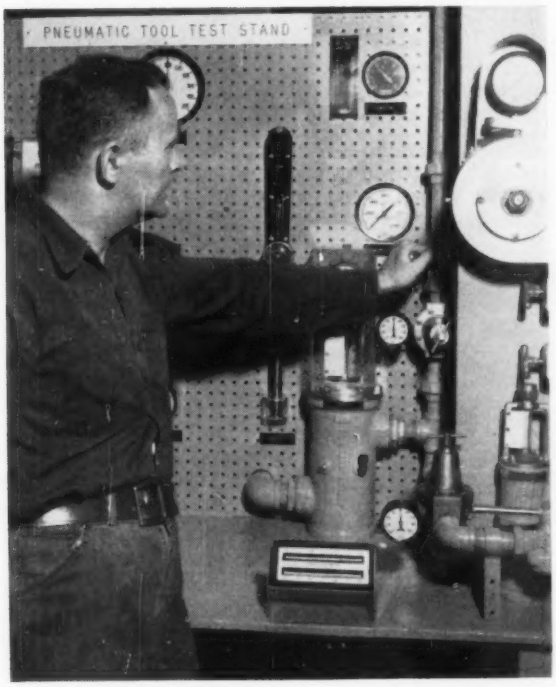


FIGURE 5—Repairman opens air valve slowly during sump pump test.

FIGURE 6—Impact wrench tester consists of 50-ton hydraulic jack welded to channel frame.

A SPECIAL REPORT
Shop Tester Checks Pneumatic Tools

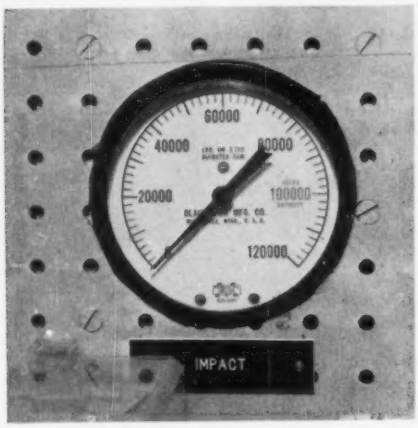


FIGURE 7—Gage registers impact effect.

FIGURE 8—Instruction tag reminds user of tool operating limits.

type flow-meter. The measurements of pump capacity against a known discharge pressure and air consumption enable a comparison of the sump pump performance against established standards.

Impact Tester. The impact tester employes the principle of pressure development in a confined liquid measured in psi by an instrument on the tester board. Primarily, loosening operations are checked since bolts corrode in the field when exposed to heat, product leaks or an industrial atmosphere making their removal difficult. An impact calibrator is used to check the amount of bolt tension developed by the tool in the tightening operation. The reading on the scale of the calibrator is easily converted into foot-pounds of torque.

The tester was designed to handle impact wrenches with a capacity of ½, ¾, 1 1½ inches. As shown in Figure 6, it consists of a 50-ton hydraulic jack welded to a channel frame. Two bolts placed upright support a block of steel. A power screw threaded in this steel block presses against the jack. As the impact is operated in the loosening direction, the screw is driven against the ram. This operation compresses the oil and creates pressure which is piped to a gage on the board shown in Figure 7.

The impact is operated in the loosening direction for 12 seconds, since a longer period will cause unnecessary wear on the anvil and hammer and no additional work is accomplished. Since this 12 second limit greatly affects tool life, we stress its importance by an instruction tag, shown in Figure 8, which is attached to each impact wrench before it leaves the repair section.

The repairman shown in Figure 9 is using the impact calibrator to check the amount of bolt tension developed by the impact wrench. Operation of this mechanism is described later in the section headed "Calibrator." A flow meter for measuring the air consumption of the tool is located in easy view of the workman. In addition, a vibrating reed tachometer, shown in Figure 10, is mounted on the tester to compare the number of blows or impacts developed by the tool against the manufacturer standards.

FIGURE 9—Repairman operates impact wrench on calibrator to find tool's torque output.

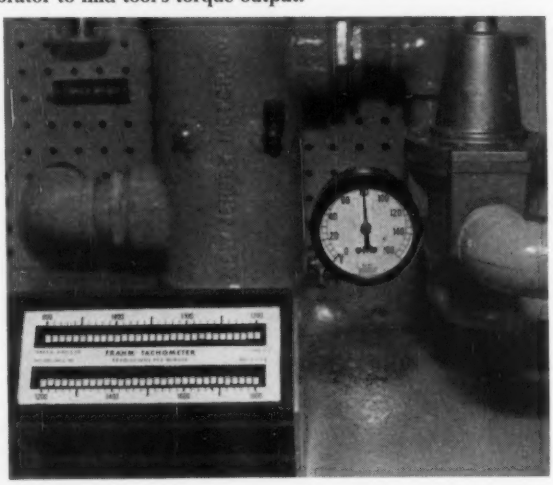


FIGURE 10—Reed tachometer used to determine impacts per minute.

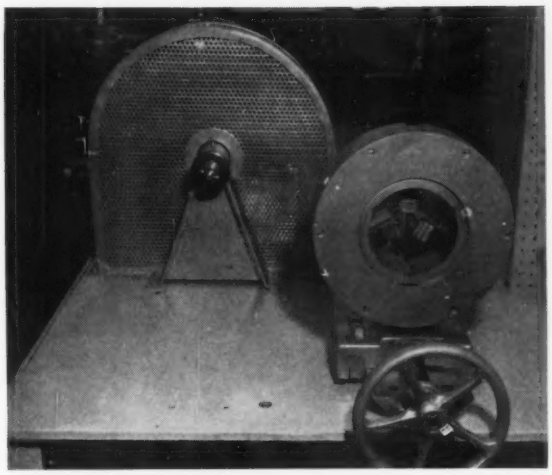


FIGURE 11—Grinder tester has machined shaft with ball and socket. Chuck (right) holds grinder during test.

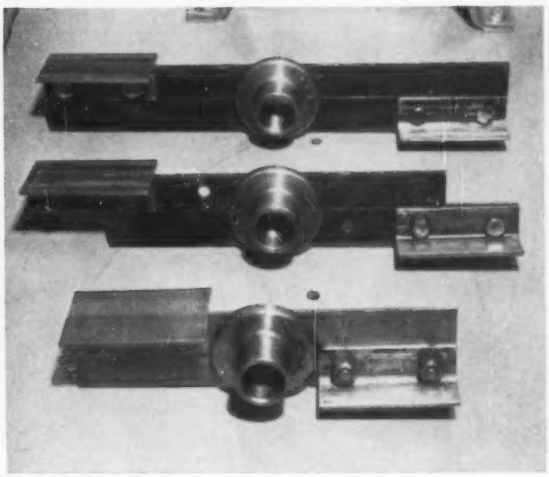


FIGURE 12—Fan blades attached to shaft simulate work performed by different size grinders.

Grinder Tester. The grinder tester consists of a stand on which a special machined shaft with a ball and socket is mounted as seen in Figure 11. Fan blades of various lengths and widths are attached individually on the end of the shaft to simulate work performed by the different size grinders to be tested. The various size fan blades shown in Figure 12 allow grinders of the 4,500 6,000 and 9,000 rpm classification to be tested. In addition, the large and small air turbines used in cleaning furnace tubes can be tested on this rig. A guard with an access door encloses the fan blades for personnel protection. The self-centering chuck is mounted on a lathe feed table which allows alignment of the tool quickly and accurately. It was found by experience that a direct connection of tool and tester resulted in excessive vibration which was eliminated by the use of pulleys and a V-belt. The friction loss, approximately 200 rpm is equal for all tools tested, therefore it is of no consequence.

A tachometer is used to determine the rpm of the tool in the free running state with no load applied. Figure 13 shows such a test being performed. Attaching the belt to both pulleys and operating the grinder as shown in Figure 14 determines the reduced rpm which simulates work being applied to the tool. We have available the standards used by a major tool manufacturer for the minimum lost efficiency of their tools with the use of the fans. However, due to the various sizes and models of grinders in the refinery, we established comparable data sheets based on actual test results. The air flow meter is again used to check air consumption while the tool is in operation. All tool testers are equipped with pressure regulators which allow any constant air pressure to be used for testing purposes. Since our plant air pressure does vary in certain locations, we are using 80 pounds as shown in Figure 15 for all tests.

Air Drill Tester. The air drill, or air motor as it is commonly called, develops a certain amount of torque

FIGURE 13—Repairmen use tachometer to check grinder rpm at no load.

FIGURE 14—With fan blade attached inside cage, repairmen check rpm of loaded grinder.

A SPECIAL REPORT

Shop Tester Checks Pneumatic Tools

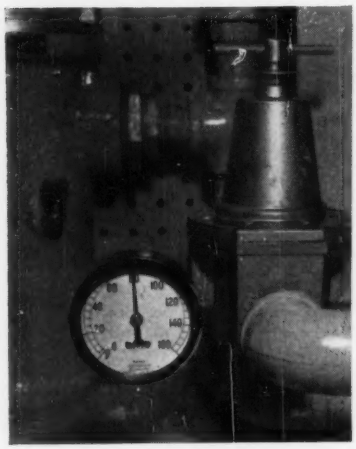


FIGURE 15—Air pressure 80 psi.

FIGURE 16—Torque wrench is used to set friction chuck for testing air drills.

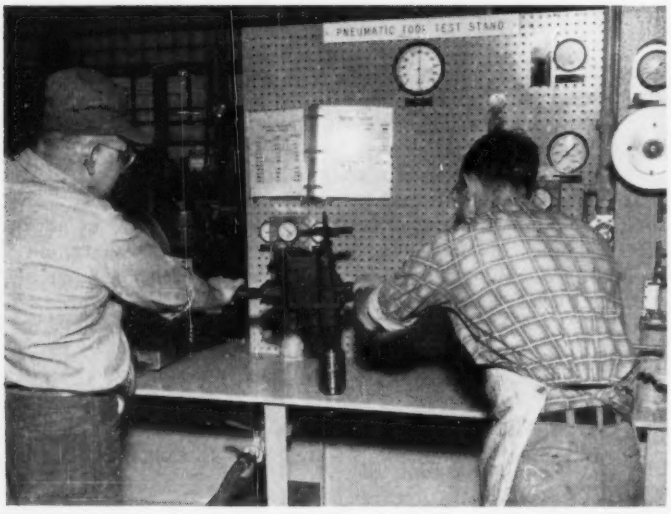


FIGURE 17—Air drill tries to overcome resistance set in friction chuck. If it can't, the torque is reduced and the test repeated.

FIGURE 18—Chipping hammer is checked on test block with a lead base.

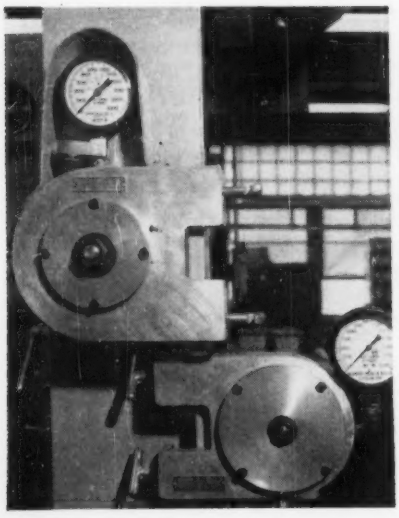


FIGURE 19—Impact calibrator shows bolt loading on top hydraulic gage.

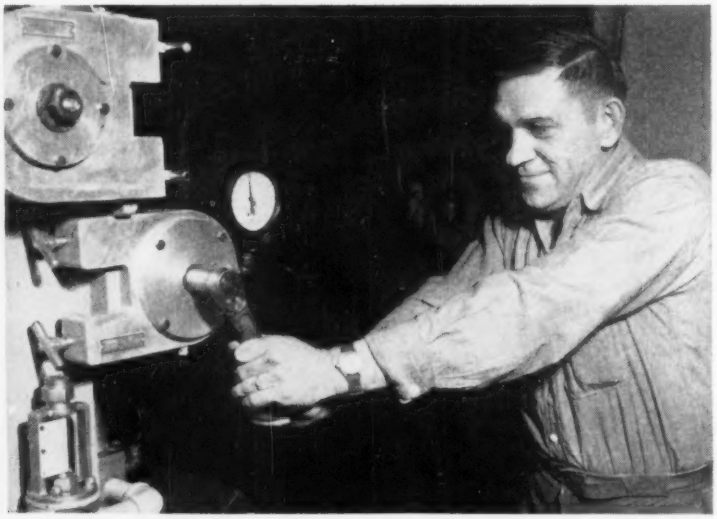


FIGURE 20—Carpenter connection wrench tested by tightening test bolt a determined amount.

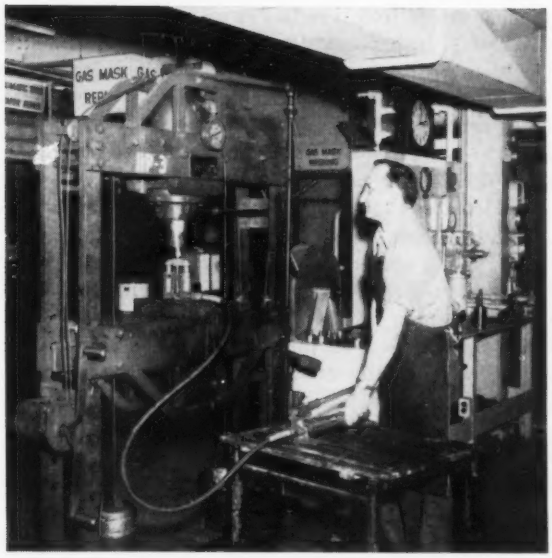


FIGURE 21—A 50-ton press tests hydraulic jack. It must hold for 15 minutes.

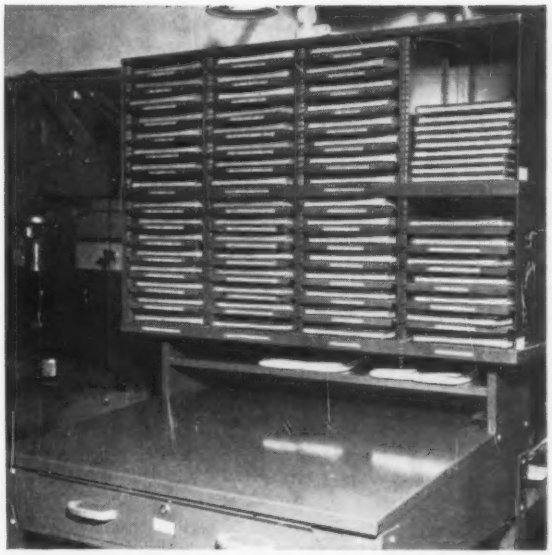


FIGURE 22—Log books keep accurate record of tool condition and cost of repair.

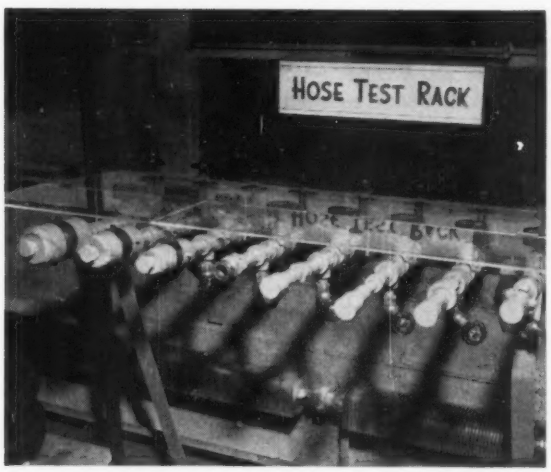


FIGURE 23—Hose test rack has eight hose fittings welded to a common header.

FIGURE 24—The proper plug is attached to free end of hose before testing.

or foot-pounds of turning effort to perform work. This tool must be able to develop the torque needed for heavy plate drilling or heat exchanger tube rolling. A friction chuck is used as the tester. It is set by applying a determined amount of torque with a torque wrench as seen in Figure 16. Once tightened the chuck retains the set friction torque. The amount of torque varies with the type and size air drill to be tested. Each air drill is tested after it is repaired and checked against established performance standards.

The test is performed after the proper torque has been applied to the friction chuck as seen in Figure 17. If the air drill cannot overcome the resistance set in the chuck, the torque is reduced and the test again performed. The air consumption of the air drill is checked during the test with the flow meter.

Percussion Tool Tester. Chipping and rivet hammers and rivet busters are classified as percussion tools. A piston driven by air strikes the end of the forming or cutting tool which is inserted in the end of the tool barrel. We have modified a test block with a lead base and incorporated it in the new test procedures. A reed tachometer and an accurate flow meter are used to determine the number of blows developed and the air consumption of the tool. A test being made of a chipping hammer is shown in Figure 18.

Calibrator. Large and small calibrators shown in Figure 19 were incorporated into the tool test stand for various testing procedures. A calibrator consists of a hollow housing which contains a hydraulic cell. It is designed to hold various sizes of plates and bushings.

A SPECIAL REPORT
Shop Tester Checks Pneumatic Tools

These plates are provided with holes for the insertion of bolts ranging in size from 3/16 to 1¼ inches. The bolt loading or tension is indicated directly on the hydraulic gage mounted on top of the housing. It is possible for a workman to use an impact developing too little or too great an amount of torque for the job. Bolts and impact wrenches are tested as shown in Figure 9 with the calibrator and impact tester so that the correct tool can be recommended for a specific bolting operation.

There have been instances where carpenter connection wrenches have failed in service even after certain part replacement was made. This was caused by failure of visual inspection to detect parts which were weaker than the renewed parts. All wrenches constructed with a ratcheting mechanism are tested by tightening the test bolt to a determined amount of tension easily converted to a torque value. In Figure 20, the repairman is testing a connection wrench with the small calibrator to check his repair work.

Hydraulic Jack Testing. The repair section maintains and repairs all portable hydraulic lifting equipment, such as jacks, rams and power units. A 50-ton capacity hydraulic press is used to test these tools in the following manner: The repair jack is placed on the adjustable table with the ram of the jack directly under the ram of the press. The jack or power unit is operated in the usual manner so that force is applied against the ram of the press as shown in Figure 21. When the capacity of the tool measured in tons is reached on the gage of the press, the pressure is allowed to remain for 15 minutes to check for holding capacity.

Record of Repairs. A new record system has been installed to be used in conjunction with our tool testing program. Frequency of replacement and maintenance hours used are kept in an easy reference form. The log book type of record keeping has been found best suited for particular needs as seen in Figure 22. After the tool has been repaired and tested, the repairman records the necessary information in the space provided for that particular tool. All new tools placed in service are embossed with a plant number. It is now a simple matter to determine exactly what repair costs are for each tool.

Hose Test Rack. The repair section repairs and makes up special lengths of air, steam, water, backfill and blending hoses. Hoses sent in for repairs are not usually marked as to detect locations, nor can we be certain even after fitting replacement that the hose is free of defects. A hose test rack has been developed to check not only the quality of work itself but also the condition of the hose.

The hose test rack as seen in Figure 23 consists of 8 hose fittings welded to a common header manifold. Five of these fittings are used for steam, water, turbine and air hose, while three are for other types of water hose ranging in size from 1½ to 2½ inches. A hinged safety cover of ¼-inch plastic encloses all connections to protect the repairman making the test from air leakage in the event the connection should fail. Our penumatic hoses are subjected to refinery air pressure which varies from 85-110 psi while steam hoses are used with pressures of 100-110 psi. Water hoses used in well-point operations and for backfill purposes carry a normal hydrant pressure of 60-80 psi.

The test is performed by connecting one end of the hose to the test rack connection and attaching the proper plug, as seen in Figure 24 to the opposite end of the hose. The required air pressure is allowed to enter the hose slowly and the valve closed when the gage indicates the proper amount. The pressure is held for a short period while the hose is checked for any pressure drop. If a drop in pressure occurs, a soap solution is used to locate the leak, and corrective measures are taken. This type of testing procedure allows more hose to be salvaged, since leaks can be located and the remaining good section used for other purposes. ##

About the Authors

Ray M. Kolb is the general foreman at Standard Oil Company's Whiting, Ind., refinery. He is in charge of the integrated Mechanical Division shops, which include the machine, boiler, welding, pipe tin, carpenter and tool repair shops. Mr. Kolb received a B.S. degree in mechanical engineering from The Georgia Institute of Technology in 1941 and an M.S. degree in mechanical engineering from The Illinois Institute of Technology in 1950. He joined Standard as a member of the Engineering Service Department in 1946 and advanced to senior staff engineer before transferring to the Mechanical Division in 1950. Here he has held positions as zone advisor (Mechanical Shops), head foreman (Shop Planning), head foreman (Welding Department), general foreman (Construction Department) and general foreman (Mechanical Shops).

Kolb

Ralph H. Lange is an area foreman at Standard Oil Company's Whiting, Ind., refinery. He supervises the General Tool Repair personnel in all phases of portable pneumatic tool repair, hydraulic lifting equipment, electric mechanical and pneumatic hoisting equipment, gas mask repair and pipe working equipment. Mr. Lange attended The Illinois Institute of Technology Institute of Design, The International Correspondence School, and The Midwest Institute (where he is an instructor of Dale Carnegie courses). He has six years experience in field and shop boilermaking and layout, five years in the boilermaker, blacksmith and painter Apprentic Training Program as an instructor, and two-and-one-half years as supervisor of the Carpenter and Paint Shop and General Tool Repair.

Lange

Can You Measure Maintenance Performance?

Yes, but only through a searching analysis of your maintenance function. These check lists are a start

Thomas B. Foster
The Emerson Consultants, Inc., New York

A SIMPLE FORMULA for measuring maintenance performance is as likely as finding the pot of gold at the end of a rainbow. Countless hours of effort have been spent to develop such a formula with only limited results. Efforts to compare current performance with past performance or to compare the performance of one plant with others on a realistic basis have been inconclusive. After over thirty years of study and analysis, we have concluded that maintenance effectiveness can be evaluated and measured, but only through the most searching analysis of a wide variety of factors which together govern the contribution of maintenance to good plant operation and profitable production.

Better Maintenance Through Better Management. These studies have clearly demonstrated that maintenance improvement is a problem of managing the maintenance function in the broadest management sense. Improvement does not lie in the area of special techniques, systems or procedures, although they are valuable tools, but rather in a balanced attack carefully guided by management. To date, systems and procedures have received the major emphasis whereas the importance of the *function* of maintenance must be recognized and good management practices must be applied to all phases of maintenance activities. Traditional attitudes, traditional standards of management personnel qualifications, traditional departmental relationships, traditional status symbols and the traditional role of supporting services must be challenged.

Maintenance Audit

In order to measure all of the tangible and intangible factors involved, we have developed a comprehensive maintenance audit. The audit covers the factors which are subject to *internal* maintenance management control, as well as those which are controlled *outside* of the maintenance department but influence the quality of the maintenance work.

Objectives. To establish a base for measuring maintenance performance, it is first necessary to define clearly the objectives being sought. These are basically simple and few in number:

- **To manage the maintenance department so as to obtain the lowest total plant operating and product costs.**
- **To keep the plant in good operating condition, thereby conserving company assets.**
- **To keep productive facilities operating the optimum percentage of total time.**
- **To maintain good employe and community relations.**

Evaluation of how well these objectives are being met involves an objective analysis of internal maintenance administration and a review of the performance of most of the staff and service functions in the plant. In reality, the external influences on the maintenance functions are more important than the specific systems used within the maintenance department for control. As a result, measuring maintenance performance and developing the means to improve are problems which must be guided and controlled by plant management.

The general philosophy and attitudes of plant and company management toward maintenance establishes the climate within which maintenance operates. These attitudes are a good indicator of the quality to be expected from the maintenance department and can be evaluated simply.

Policy. Maintenance and production supervision must be guided by an adequate policy which spells out the desired level of maintenance and aids production in balancing maintenance requirements with the burden of meeting production schedules and sales forecasts. Without policy guidance in this area, maintenance either guesses at the correct level of maintenance or protects itself by over-maintaining. Production lets expediency prevail and moves from one crisis to the next while maintenance springs into action to handle emergencies and breakdowns when the button is pressed.

Even without general policy guidance, maintenance performance and its contribution to overall plant effec-

tiveness can be measured and individual areas of weakness can be singled out.

Experience has shown that there are certain administrative relationships, techniques, procedures and controls which ought to be present in any plant if the maintenance function is to do the best possible job in reaching its objectives. These are the available tools for managing the maintenance function. The level of performance is revealed by the skill and effectiveness with which management applies these tools.

The maintenance audit is designed to reflect the degree in which the company, plant and maintenance management is employing the best available techniques and controls to reach their objectives. Many of the factors considered require an objective judgement evaluation of the level of performance while others provide quantitative measures of the success a plant is achieving. In the audit, we have grouped these factors into nine basic categories which must be analyzed objectively to arrive at a realistic measure. The audit consists of 215 items which must be carefully analyzed and scored to develop a rating for the maintenance department. The scores are totaled and weighted to produce a rating by category and in total for the plant. The audit indicates areas of weakness and points attention toward the areas demanding corrective action. Subsequent audits measure the degree of improvement made and can also provide the base for interplant comparisons. The following table lists the categories and illustrates a sample rating for a plant before and after management had started a comprehensive improvement program:

Typical Audit Results

Categories	Initial Audit	Audit One Year Later
1. Organization	51.0	73.9
2. Department Relationships	54.9	73.3
3. Planning and Scheduling Controls	20.1	83.7
4. Preventive Maintenance	6.6	30.2
5. Workload Control	15.1	47.1
6. Productivity Control	38.5	49.2
7. Purchasing and Stores	40.0	62.7
8. Engineering and Inspection	47.2	54.5
9. Cost Control	17.3	40.5
TOTAL	32.3	57.2

The ratings vary widely from plant to plant both in individual categories and in total ratings for the plant. The Typical Plant Audit Ratings illustrate this variation between plants and the degree of improvement made in subsequent audits.

Typical Plant Audit Ratings

Type of Plant	Initial Rating	Second Rating	Gain
A Chemical Plant	31.1	57.6	26.5
An Oil Refinery	28.8	68.2	39.4
An Oil Refinery	46.4	68.7	22.3
A Paper Mill	44.0	75.0	31.0
A Steel Mill	32.6	64.3	31.7

A rating of 100 indicates theoretical—perfect performance. We do not expect this ever to be achieved although continuing audits guide management efforts in striving for this goal.

Each category in the audit control is a potential for improved performance.

An interesting side light is the quite close correlation between the improvement percentages recorded and the increase in productivity, in those instances where both audits and ratio delay studies have been made—usually ± 2 percentage points.

Organization. The structure of the maintenance organization and its relationship to the production department it serves not only effects the production management but also the productivity of the men. If management provides the proper organization and administrative tools it has provided the opportunity for the individual man to produce more effectively. More important, the opportunity for the individual, his associates and his superiors to recognize and measure his contribution has been provided. Almost without exception men want to be productive, proud of their work and to do a full day's work. It is management's job to organize and administer activities so that the men are not prevented from being productive.

Analyze Your Department. The plant manager, plant engineer or maintenance superintendent must objectively answer the following key questions taken from the audit as well as many others after a searching analysis of his organization:

- **Are all necessary maintenance functions provided for, clearly separated and properly arranged?**
- **Are the number of levels of the supervisory organization at a minimum, commensurate with a manageable span of control?**
- **Is management authority and responsibility delegated to the proper level and carefully defined for each level?**
- **Are position duties, responsibilities and authority in written form, positively stated and supported by written procedures which insure that each individual can actually perform the duties assigned?**
- **Are the methods of selecting supervisors fair, systematic and reasonably scientific?**
- **Is the supervisory effort diluted by the use of temporary or quasi-supervisory hourly rated supervisors?**
- **Is there a suitable program of wage and salary administration including job evaluation and merit review?**
- **Are supervisors trained in the execution of their management duties as defined in their individual position descriptions?**
- **Are replacements being trained for key supervisors on an organized basis?**

The results of the audits made in this category show a wide variation in ratings between plants with average scores normally higher than the overall rating for all categories in the plant. Since organization principles are well known, corrective action in this area is reasonably clear cut but discipline and careful planning are required if organization defects are to be corrected smoothly. Normally improvement in this category can be achieved in a reasonably short period. Average rating improvement is 21 points or 37 percent.

Department Relationships. A surprising number of the factors which contribute to or control maintenance

performance are outside the direct control of maintenance management. Thus, plant or higher management must take an active part in assuring that all factors contributing to maintenance performance are balanced and coordinated. The audit section concerned with department relationships is primarily focused upon the operating organization and the industrial relation activities which influence maintenance performance. Other specific external functions are covered in other sections of the audit.

Operating Department. Typical examples of the elements to evaluate in the Operating-Maintenance relationship are illustrated by the following sample questions from the audit (answers should be yes to all questions):

- **Is the concept of operating proprietorship a basic plant philosophy? i.e., are operators regarded as equipment owners?**
- **Does Maintenance Management regularly attend and contribute to operating, planning and production scheduling meetings?**
- **Are there established job responsibilites for operating-maintenance liaison?**
- **Must the operating department justify on a review basis the amount of emergency work incurred?**
- **Do all orders for maintenance and repair work require operating approval?**

Industrial Relations policies exert tremendous influence over supervisory effect on discipline, productivity and utilization of the labor force. Plant environment sets the tone for productive efforts through high standards and uniform discipline. Personal relationships in the individual work day contribute most heavily to the satisfaction and happiness of the worker and thus to his motivation and productivity. The role played by the supervisor who is governed by industrial relations policy assumes prime importance. The audit of the Industrial Relations practices and policies includes analysis of the answers to such questions as:

- **Are Industrial Relations policies primarily directed toward peace at all costs or toward the protection of management and its rights?**
- **Does maintenance management participate in and contribute to pre-contract negotiations planning?**
- **Are grievances submitted in writing and steered through maintenance supervision and management for disposition?**
- **Are maintenance supervisors given specific instructions of a positive nature for dealing with the bargaining unit at the first step level?**
- **Are candidates for hiring or promotion subject to standard aptitude, intelligence and personality tests as well as minimum qualifications standards for positions?**
- **Is maintenance first line supervision expected to administer policy in terms of wage administration, discipline, classification, change, promotions and demotions?**

Systems and procedures work can improve planning, improve scheduling and eliminate waste in the maintenance function. However, Industrial Relations policy and practice and contractual arrangements as well as basic management attitudes and discipline have as great if not greater an effect upon the performance of the maintenance function. Improvement in this category requires careful long range planning and coordination. Normally concrete results take longer to achieve because of the traditional practices that are accepted throughout the plant and because changes deal with supervisory and employe attitudes. Further Company-Union relationships are frequently involved.

Average improvement over short or intermediate periods have been 22 points or 44 percent.

Planning and Scheduling Control. This portion of the audit measures those activities, concepts, and techniques employed in the planning, scheduling and execution of maintenance work. It evaluates how well and how completely the department is handling the problems involved in identifying job requirements, organizing job requirements in terms of priority and manpower needs, scheduling job requirements to the optimum advantage of the plant and controlling work execution in relation to schedules.

In evaluating performance in the area of planning and control, we must evaluate answers to questions such as:

- **Is there a work order system involving written orders for all types of maintenance as well as construction work?**
- **Is an impartial and thorough analysis made of every job before the work is scheduled?**
- **Does the job analysis list the job steps and the labor requirements in correct detail on the work order?**
- **Are all special tools, equipment or services identified on the work order?**
- **Is a full day's work planned and scheduled for every maintenance man every day?**
- **Does the planning predict the future work load in sufficient detail for each craft to permit forecasting of bottlenecks and the need for priority adjustments?**
- **Is there a disciplined or controlled priority system in effect?**
- **Does the schedule force a review of every job in progress every day?**
- **Is there a system coordinated with operations to plan plan for shutdown and other types of major maintenance on a long term basis?**
- **Does the system highlight excessive repairs to equipment, lack of maintenance, poor maintenance, repetitive maintenance or poor design?**
- **Does the planning and scheduling system free the foremen to supervise their men?**
- **Judging from plant observations, are there recoverable delays due to lack of material, tools or improper manpower assignment?**
- **Are causes for deviation from schedule and deviation from standards questioned?**
- **Do maintenance work schedules interfere with production schedules as little as possible?**
- **Is shop work such as machine shop and fabricating work coordinated with field requirements?**
- **Is material scheduled to the job site before it is needed?**
- **What percentage of total scheduled hours are actually worked as scheduled?**

A SPECIAL REPORT

Can You Measure Maintenance Performance?

- **What is the percentage of emergency work in manhours?**
- **What is the percentage of total manhours of maintenance work planned and forecast daily and weekly?**

Our experience with audits of the planning, scheduling and control activities produces a wide variation in initial scores. With the average rating being considerably lower than the overall plant rating. However, attention to the methods and procedures, the assignment of responsibility for planning and scheduling has produced marked improvement in this area. The average improvement in our experience has been 47 points in the ratings or 142 percent as a result of concentrated attention to planning and scheduling activities.

Work Load Controls. This portion of the audit is designed to evaluate how completely the department is able to measure its work load, balance manpower with work load, forecast desirable changes in manpower and influence priorities for the purpose of maintaining the most efficient utilization of maintenance departments' resources. Specific factors evaluated in work load control are illustrated by the following sample questions:

- **Is there a means of determining accurately by craft the total manhours of work in process as well as the manhours of work ahead of each skill?**
- **Can craft imbalances be forecast?**
- **Can repairs, preventive maintenance, emergency maintenance, alterations and capital or new construction work be identified in manhours and total costs?**
- **Are manning requirements forecast based upon long term shutdown schedules, schedules of new construction projects, backlog records and analysis of repetitive work?**
- **Are the number of mechanics to areas or production departments or assigned to standing or open labor accounts excessive by reason of inadequate control of routine repair work at its source?**
- **Are either the numbers of separate crafts excessive to plant needs or are jurisdictional restrictions excessive?**

Our experience in this area indicates extreme variations in initial ratings although the average is approximately the same as the overall plant rating average. Positive maintenance improvement programs have resulted in average improvement in this area of 42 points or 107 percent with short term recovery characteristics.

Productivity Controls. This section of the audit is designed to indicate the effectiveness of the organization in first measuring and then improving the productivity of its manpower. It includes evaluations of factors which demonstrate the presence of adequate measures to control productivity or the presence of definitive plans for improvement of productivity. This area has received considerable attention and there exists great differences of opinion concerning the degree to which maintenance productivity should be measured on a continuing basis. This is primarily an outgrowth of the attitude that maintenance work is non-repetitive and that it frequently costs more to measure maintenance productivity than the benefits derived. We do not agree with either of these premises. Through study of maintenance activity, repetitive patterns can be developed. This is demonstrated forcibly in the standardization of turnaround practices of the petroleum industry. Secondly, the means to measure productivity of maintenance manpower at a reasonable cost exists and are being used effectively. This audit category covers questions such as:

- **Are labor standards available based upon time study, work sampling or other techniques and expressed in maintenance schedules and productivity reports?**
- **What is a maintenance productivity index as determined by ratio delay studies? (See below.)**
- **What is a percentage of plant downtime for mechanical reasons? (Should be less than 2 to 5 percent.)**
- **Do shop supervisors control machine feeds, speeds and cutting tool specifications, etc.?**
- **Are specific studies made of turnarounds to single out and recommend continuing improvements to reduce costs or improve on-stream efficiency?**
- **Is there a methods improvement and cost reduction program in existence?**
- **Are studies being made on a program basis of the factors influencing work performance such as work authorization, planning and scheduling, shop facilities, tools, mobile equipment, material scheduling, equipment standardization, and non-productive time?**
- **Are studies being made regularly to identify productivity losses incurred as a result of contract agreements or misinterpretation of contract provisions?**

The results of ratings in this category are considerably lower than the overall ratings in all categories. Even after attention in this area, the ratings have remained lower than the over-all audit average. This would tend to lend weight to opinions that maintenance productivity cannot be profitably increased. We do not believe this. Experience indicates rather, that other factors such as organization, planning and scheduling, preventive maintenance and other areas of an improvement program must be in a controlled state before efforts to improve productivity can be effective. For this reason, the measurement of productivity as a specific technique in the control of maintenance, must be correlated with specific attention to the other factors covered in the audit. Further, the analysis of repetitive work and the comprehensive study of work methods and work patterns requires time and a sustained intense desire on the part of management for control.

Ratio Delay Studies. Until the plant is in a position to control productivity through reliable standards, ratio delay studies provide extremely useful means for periodic measurement of productivity and identification of specific productive loss elements. The following table illustrates sample results obtained from such studies:

Results of a Ratio Delay Study

	Plant A
Productive Work	39.5%
Idle—late starts and early quits	4.6
idle on job	4.3
excess personal time	5.3

Waiting—for instructions	3.3
for tools and materials	5.3
for release of equipment	2.6
for other crafts	6.1
for plant protection	.2
Travel—To and from jobs	4.6
Receiving instructions	6.0
Contractual loss and present practice	18.2
	100.0%

The typical example on the preceding page is slightly higher than the average. Analysis of the results of many ratio delay studies are revealing.

On the average, 10 percent of the working day is lost due to provisions of a union contract, that is—make ready time, wash-up time, personal time, coffee breaks, tool put away time, etc.

Twenty-three percent of the working day is lost because of abuses to contract provisions and a lack of simple discipline in the work force. This time consists of late starts, early quits, excess personal time, unexplained idle and other excesses. Of this, approximately 70 percent is recoverable through good organization, adequate supervision, and careful administration of existing company policy and contractual agreements.

Thirty-three percent of the net working day is lost as a result of poor management organization and the controls associated with planning, work instructions, coordination of work elements involved, such as—materials, tools, other skills required, etc. In this category of losses normally 40 to 50 percent is recoverable.

Preventive Maintenance. The Preventive Maintenance portion of the audit measures the degree to which preventive maintenance is being used on a systematic basis to provide the lowest total plant operating cost. It provides a measure of how well the preventive maintenance procedures and techniques are integrated with the overall maintenance control program. It measures the design effectiveness and the feedback characteristics for the purpose of determining the lowest cost maintenance program for each item of equipment maintained. No maintenance at all may be the least costly or almost complete preventive measures may be the least costly. For individual items of equipment, any degree of preventive maintenance activity between these two extremes may be the correct level of maintenance. A good preventive maintenance system permits the analysis to determine the level of maintenance for each major item of equipment which will produce the least total cost.

Factors to evaluate in reviewing preventive maintenance activity include questions such as:

- **Is there a well designed preventive maintenance program in operation?**
- **Does the preventive maintenance program cover all items of equipment in the plant even if they are covered only to the extent of determining that it is less costly to exclude the items from periodic attention?**
- **Are check lists used in guiding mechanics covering lubrication, periodic servicing and scheduled overhauls?**
- **Are preventive maintenance inspections ordered and scheduled on separate orders for each group of machines or equipment?**
- **Are the frequencies of preventive maintenance attention determined by factual technical analysis?**
- **Are production personnel trained to operate equipment properly to avoid unnecessary damage, wear and failure?**
- **Is a systematic program in effect to provide the latest and best lubrication technology to the plant?**
- **Are spare parts requirements and interchangeability a basic part of the preventive maintenance program?**
- **Is the continuing analysis of metal corrosion, fatigue, wear and erosion rates being thoroughly done and influencing the determination of preventive maintenance frequency?**
- **Are the applications of preventive maintenance service forecast and covered by an overall plant annual schedule?**

The rating of plants on their performance of preventive maintenance produced a wide variation in initial scores with the category average being slightly lower than the overall audit plant average. Here again, after attention to improvements in this area the scores obtained in followup review remains considerably lower than the over-all plant average. This is a reflection of the time and detail required in the development of a thorough and comprehensive preventive maintenance program. Average improvement is 20 points or 51 percent.

Purchasing and Stores in most plant organizations is a function outside the direct control of the maintenance organization. This category of the audit is designed to measure how well Purchasing and Stores is servicing maintenance. It examines the economic factors involved in inventory control, procurement practices, storage security and the availability of materials at point of use.

The audit measures the effectiveness of this function through questions probing the services provided and the communication processes provided.

- **Does maintenance participate in the selection of individual manufacturers or suppliers?**
- **Is maintenance a key participant in the interchangeability and standardization programs?**
- **Does purchasing notify maintenance of any change in original commitments?**
- **Are perpetual inventories of all materials and parts maintained centrally?**
- **Does maintenance participate in the establishment of minimums and maximums of stock items?**
- **Does maintenance participate in the addition or deletion of materials or parts items from regular stock?**
- **Are maintenance materials stored in secure areas and disbursed by authorized personnel?**
- **Are materials issued and delivered to the job site before the jobs are scheduled to start?**
- **Is there a salvage and reclamation program in existence and do the items returned to storage custody have some reasonable value?**
- **Do stores accept less than unit quantity for credit? i.e., can you return less than a full coil of tubing, etc.?**
- **Are some stores located close to point of use for low value fast moving items?**

- **Is there an established review committee to decide on obsolete, scrap and excess items?**
- **Is there an accepted "cost-of-owning" figure used in stock or special order decisions?**
- **Are arrangements in effect with local suppliers for frequently used items to be supplied periodically from an annual order?**
- **Are inventory dollar values readily available and routinely used in materials management decisions?**

In evaluating the purchasing and stores functions, the variations in initial scores are less marked than in most of these other categories. In addition, the average scores are considerably higher than the over-all plant rating, which indicates that materials management has frequently had more attention and is routinely better organized than the maintenance function itself. After attention to the purchase and stores area, the final scores remain higher than the over-all audit ratings with average improvement being 22 points or 56 percent.

Engineering. The influence of the engineering department, particularly if inspection falls within this area, can influence maintenance effectiveness to a large degree. This portion of the audit is designed to measure the effectiveness with which communications, correlation and coordination of efforts in engineering service to maintenance is provided to make the greatest combined contribution to the plant. Evaluation of engineering activities is achieved through questions such as the following:

- **Are controls in existence to insure engineering attention to all capital additions or alterations to existing plant?**
- **Are capital additions or alteration designs subject to maintenance review prior to final approval?**
- **Are drawings and related engineering data released to maintenance in package form in proper working sequence?**
- **Does the parts interchangeability and equipment standardization program have full impact on design and selection of equipment?**
- **Are design drawings released by prearranged schedule tying in with maintenance manpower availability and project priority?**

About the Author

Thomas B. Foster is vice president of The Emerson Consultants, Inc., New York City, where he is in charge of the general direction of consulting assignments in a variety of industries (including petroleum). These duties include those assignments whose objectives are to improve plant maintenance performance. Mr. Foster holds a B.Sc. degree in business administration from Ohio State University. He joined Emerson in 1946 and became a partner in the firm in 1951. In 1959 he was appointed to his present position as well as director of the firm.

Foster

- **Are staff engineers available and used for special equipment failure studies, material suitability studies, etc.?**
- **Are there long-term, high-cost or unpredictable situations in the plant indicating unsolved process and engineering problems?**
- **Are project estimates prepared in sufficient detail to constitute real control over project costs?**
- **Is sufficient engineering talent available to avoid the necessity of engineering by operators or craft personnel?**
- **Is corrosion inspection data integrated with the maintenance program?**
- **Are inspection responsibilities clearly defined and divided correctly between engineering and maintenance?**

The average engineering rating is considerably higher than the over-all audit averages. Improvement efforts produce an average gain of 27 points or 46 percent.

Cost Control. This category is designed to measure the ability of maintenance management to identify high cost areas within its control and to conduct penetrating analysis as to cause. This category also measures the department's ability to communicate clearly with other interested departments and to top management relative to cost problems requiring cooperative action.

- **Are estimates of labor and material costs made for each maintenance job?**
- **Are labor and material charges accumulated by individual work order by accounting?**
- **Does accounting, at regular intervals, compare the actual cost of maintenance with the budget and show variance?**
- **Are accounting reports published currently?**
- **Are process unit values currently available which represent values per operating hour?**
- **Are there established maintenance "yardsticks" such as the ratio of maintenance cost to product cost, plant assets, labor to material rates, etc.?**

The results of ratings on cost control show less than average variation between plants and all plants covered rate lower in this category than the over-all audit rating. Attention to the weakness in cost control produces greater than average improvement. The average improvement made has been 43 points or 107 percent.

Advantages of a Maintenance Audit. The maintenance audit has demonstrated in use the following advantages:

- A simple numerical expression of status and accomplishment.
- A useful method for evaluating the many intangible factors involved.
- A useful method of establishing common definitions, common objectives and common values.
- A realistic method of comparison in management control between plants without having to factor by differences in plant size, age, condition, complexity or severity of processes.

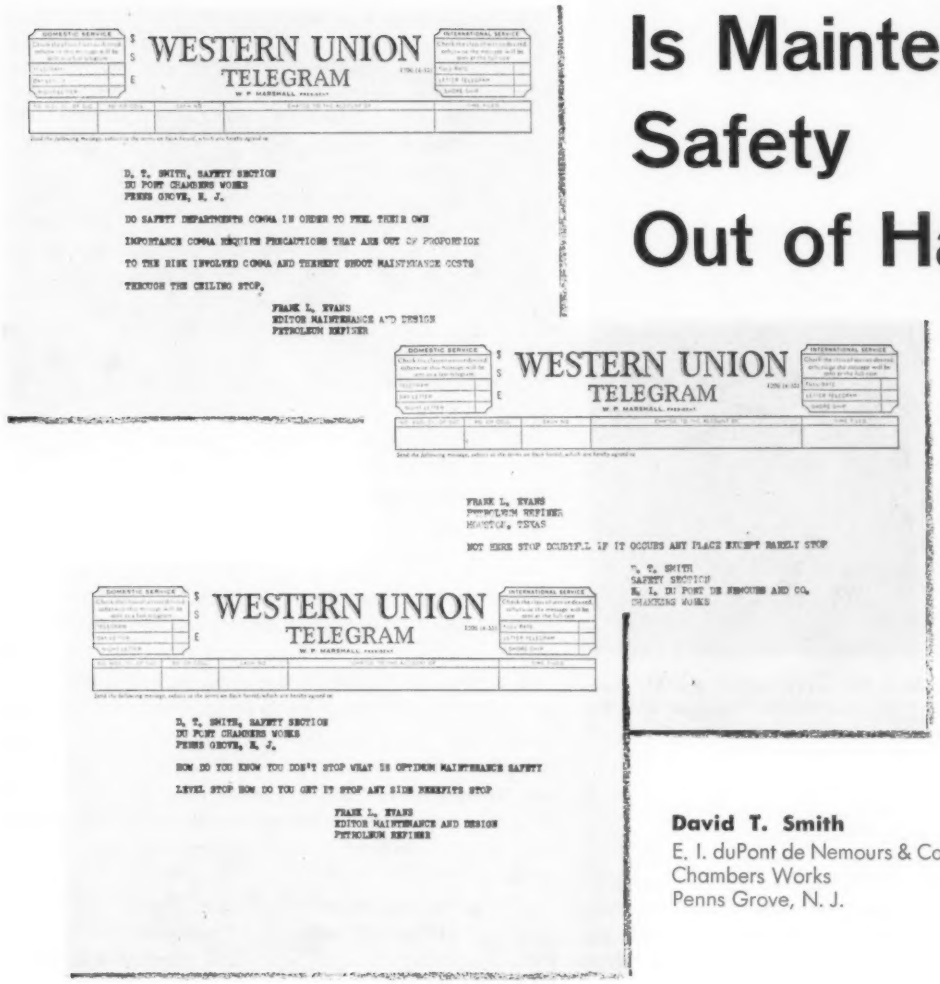
A number of companies are finding the audit to be an increasingly valuable means of measuring performance and pinpointing areas of potential improvement.

##

A SPECIAL REPORT

MAINTENANCE

Is Maintenance Safety Out of Hand?



WESTERN UNION TELEGRAM

D. T. SMITH, SAFETY SECTION
DU PONT CHAMBERS WORKS
PENNS GROVE, N. J.

DO SAFETY DEPARTMENTS COMMA IN ORDER TO FEEL THEIR OWN IMPORTANCE COMMA REQUIRE PRECAUTIONS THAT ARE OUT OF PROPORTION TO THE RISK INVOLVED COMMA AND THEREBY SHOOT MAINTENANCE COSTS THROUGH THE CEILING STOP,

FRANK L. EVANS
EDITOR MAINTENANCE AND DESIGN
PETROLEUM REFINER

WESTERN UNION TELEGRAM

FRANK L. EVANS
PETROLEUM REFINER
HOUSTON, TEXAS

NOT HERE STOP DOUBTFUL IF IT OCCURS ANY PLACE EXCEPT RARELY STOP

T. T. SMITH
SAFETY SECTION
E. I. DU PONT DE NEMOURS AND CO.
CHAMBERS WORKS

WESTERN UNION TELEGRAM

D. T. SMITH, SAFETY SECTION
DU PONT CHAMBERS WORKS
PENNS GROVE, N. J.

HOW DO YOU KNOW YOU DON'T STOP WHAT IS OPTIMUM MAINTENANCE SAFETY LEVEL STOP HOW DO YOU GET IT STOP ANY SIDE BENEFITS STOP

FRANK L. EVANS
EDITOR MAINTENANCE AND DESIGN
PETROLEUM REFINER

David T. Smith
E. I. duPont de Nemours & Company
Chambers Works
Penns Grove, N. J.

Letter to Frank L. Evans,
Editor, Maintenance and Design,
PETROLEUM REFINER,
Houston 1, Texas

Dear Frank:

Your last telegram demands more than a telegram for an answer. We know that the safety engineer at our plant does not require precautions that are out of proportion to the risk involved, *because he only recommends instead of requiring*. The final decision as to precautions lies with the line organization responsible for the maintenance work at our plant. This is common to all Du Pont organizations for the safety personnel act solely in a staff or advisory capacity. The line organization must be delegated the authority to make the decisions because they are held responsible for the success or failure of their work as to safety, just as they are for costs, quality, meeting schedules, etc.

We hold that all injuries can be prevented. In every injury, study afterward has shown that steps could have been taken effectively to reduce the likelihood of its happening. We also believe that prevention of injuries is in the common good, both for the employe, his family, the general public, and for the company. Therefore, it is our policy that all activities of the company shall be carried out without injury to the employe or the public. This policy must be carried out by all levels of the line organization, and each person is responsible

A SPECIAL REPORT

Is Maintenance Safety Out of Hand?

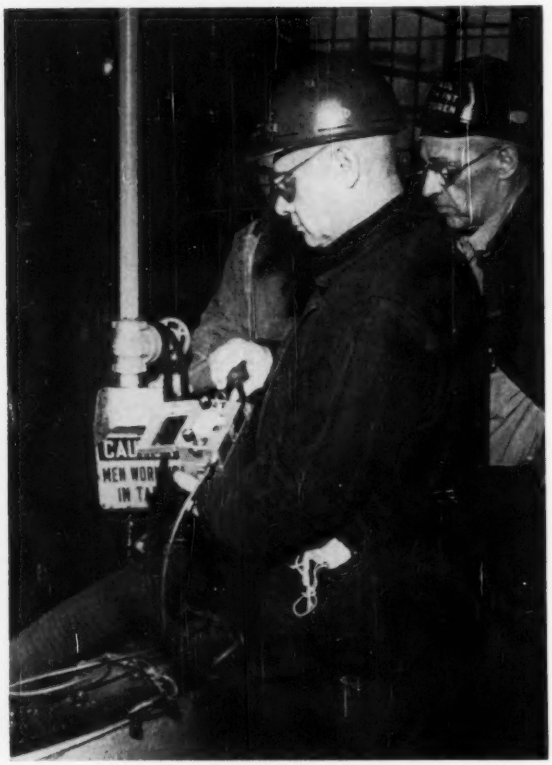


FIGURE 1—To provide a safe work site, a test for flammable vapors is made by the maintenance foreman and witnessed by the operating foreman.

for the safety of those entrusted to his supervision. If he cannot deliver an acceptable execution of this safety responsibility consistently, then it is up to his line organization to help him find out why and to assist him in improving his performance. If these efforts fail, then a change in organization will be made. Continuing poor results in safety cannot be tolerated any more than any other type failure in operation.

The safety engineer, as a management consultant in this particular field, is there to help maintenance line organization by his observations, his analyses and his recommendations. The decision on his recommendations is up to the line organization, however, as they are carrying the ball. Because his ideas are delivered as recommendations, they must be backed by adequate justification and proof, just as any other engineering recommendation to management. In summary, *we know that the safety department does not require precautions that are out of proportion to the risk involved because:*

- It is not permitted to assume that authority.
- All recommendations must be justified to the line organization on the basis of logical analysis and conclusion.
- Line organization is required to make the decisions.

Optimum Safety. In answer to your second question, "What is optimum maintenance safety?" prevention of *all* injuries is our optimum because it is our goal. While we have frequently achieved periods of several million manhours worked without a time-losing or permanently disabling injury, we freely admit that we have not yet achieved success. However, since we are still gradually improving, we keep on trying. Our management feels that this goal is a reasonable one, because analysis of our failures shows that each could have been prevented.

Achievement of safety has been found by our management not to be a function of increased costs but directly related to planning, ingenuity in meeting problems, and hard work. Without exception, a safe job is a well planned, efficient, economical job. Those where we have failed in safety have nearly always shown weaknesses in planning, training, checking, supervision or other management tasks, and have also resulted in less effective jobs from other standpoints than safety.

We do not have figures available to show how the cost of safety measures compares with savings in direct injury compensation costs. We suspect that in some areas of safety activity we spend more money for safety measures than the compensation dollars saved. However, when we consider the indirect costs of injuries, the far-reaching effects that accidents have on production and sales, on the employe and his family and on our public relations, our management believes it is good business to prevent injuries.

"How do you get it?" you asked in your wire.

The base on which we build our program is the realization that the company and the works manager will not accept failure. There is no more impelling factor to a member of a line organization than the realization that unless he achieves safety in the activities and personnel under his supervision that his personal future and earnings with the company may be jeopardized. This is not expressed as a negative factor, but the knowledge of the company position is clear cut and well understood.

The same requirement holds for the nonsupervisory employe. Deliberate violation of safe methods or continued inability to carry out safe methods cannot be permitted.

The same management tools are needed for good

FIGURE 2—Everybody involved puts their locks on a switch before working on moving equipment.

FIGURE 3—Specialized equipment makes repetitive jobs safe and economical.

FIGURE 4—Safe access to elevated jobs is met by special work platform securely fastened to fork lift truck.

safety as for securing other desirable attributes of maintenance work. There is no magic method in our experience that will permit us to achieve good safety while neglecting other factors, nor that will short-cut the hard work and eternal vigilance needed to achieve good over-all management. Stated another way, the diligent planning, training, effective communication and close supervision needed for good safety result in increased over-all job efficiency.

Safety Techniques. Some of the techniques used here in these fields may be of interest.

No job is too complex or too simple to warrant its being done without prior planning. Repetitive jobs can be and are analyzed by steps, key points, and hazards till they need only periodic brush-up. Nonrepetitive and complicated jobs call for and get individual analysis, group discussions and firm plans before work is started. To prevent overlooking important hazards, we break the job down into general headings.

- **Provide a safe work site** (Figures 1 and 2). Chemical exposures, heat exposures, falling or moving objects, access by stairs or ladders, etc.
- **Provide safe tools and equipment** (Figures 3 and 4). Selection, design, inspections personal protective equipment, protection from moving or sharp parts.
- **Provide a safe method** (Figures 4 and 5). Major steps, detail steps, hazards at each, safety answers.
- **Train in safe methods** (Figure 6). Group discussions, demonstrations, posted rules, rechecks.
- **Get right attitude** (Figure 7). Person-to-person contact plan, group safety meetings, promotional material, participation, and insistence on complete adherence to agreed-on safe methods.

Example. A major operating unit overhaul during shutdown, such as a sulfuric acid plant, furnishes a good example of the approach. The area maintenance engineer and key members of his staff sit down with the supervision of the unit concerned, well before the shutdown. The scope of the work is carefully reviewed, the condition of the operating equipment is discussed, the materials and repair equipment settled and the major methods of execution agreed on. Time schedules are set, manpower scheduled, and so on. Then, a hazard analysis of the whole job is made, and plans are made for handling training, communications, and on-the-spot direction.

Safety Like Defensive Football. Actually, the efforts of the line organization are very similar in approach to those of the coaching staff of a major football team for defense before the "big game."

Considerable time and effort, before the contest, is spent studying the different ways the enemy is most likely to penetrate the defense. In maintenance, what are the possible sources of injury?

In football, we would decide on the assignment of our front line, our linebackers, and our backfield men and the formations they would use. Each has both specific assignments and general assignments. In maintenance, our front line defense is the removal of the haz-

ard. Our linebacking consists of taking steps to guard against hazards we can't remove. Our backfield is the personal protective equipment we provide and the emergency measures we take to safeguard or reduce the severity of injury when our other efforts have failed. Good pre-planning means that our front line will stop most of the hazards, the linebackers will take care of the few we can't meet at the line, and then only occasionally will a hazard get through to our backfield for the safety man to down with a last ditch tackle.

FIGURE 5—Life belts worn around the chest provide a safe method.

FIGURE 6—Articulated crane provides safe method for unusual jobs.

FIGURE 7—Posted safety rules furnish a valuable reference.

All football team members are coached in the execution of game fundamentals weekly (such as blocking, tackling and pass interception) just to keep their skills sharp, and so they will automatically respond with the right move in case of emergency. We do the same thing with procedures for locking-out moving equipment, tank entry, scaffold work, eye protection, etc.

Shortly before the actual game, the team is given a chance to acquaint themselves with the actual field conditions by a light practice, and the coaches get a last minute chance to observe that every man is properly equipped, in good shape, and displays the right attitude. During the five-minute, tool-box meeting on the site, each shift can achieve all of these; so we use it extensively.

As the football game progresses, huddles are held to talk over the effectiveness of the defense, to get additional direction from the coach and to make changes in plans to meet changes in field conditions. The coaches seek advice from spotters in the stands who can have a different view of the field. We do the same in maintenance safety with short progress reviews, and by changing tactics to meet any new hazards or conditions which have arisen. The advice and help of the safety engineer is used, because he can give a fresh viewpoint of the job.

Good housekeeping is an essential part of good maintenance, we believe. Our definition is simple:

- All grounds and floors must be level, neatly raked or finished, and free from ruts, holes or ankle-turning stones or hazards (Figure 8).
- All materials, containers, and movable equipment must be stored in an orderly geometric fashion. Rows must be parallel, of uniform height and aisle spacing. Storage should be parallel to fixed boundaries, such as roads, building walls, fences, etc.

FIGURE 8—Safety "know how" is gained by group discussions.

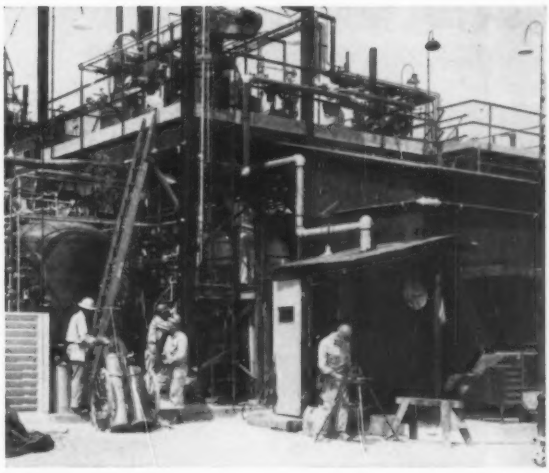


FIGURE 9—Area ground must be neatly raked and free from holes and ruts.

- All tools, implements, and equipment must be kept in planned storage locations when not in use. When temporarily at a job site, unused tools must be placed in an orderly fashion out of the way of traffic (Figure 9).
- There must be complete freedom from trash and refuse, such as paper, sticks, wire, discarded gloves, scrap pipe, bolts, gaskets, etc. Unused new material must be returned to supply sources.

Each maintenance group is responsible to see that each job is not only left in a good housekeeping condition at the end of their shift but that good housekeeping conditions prevail throughout the work area. Separate portable trash containers for metal and for general trash are provided.

Example. The importance of three-deep defense against hazards was highlighted recently. There was a repair to be made at a location at fourth-story height outside one of our manufacturing buildings which required a scaffold. A site inspection was made, a standard patent pipe scaffold was ordered installed and the scaffold crew, who do this type of work daily, were moved to the scene. A five-minute, tool-box safety meeting was held by the foreman, the scaffolding material was inspected, the men's work clothing and protective equipment were briefly checked and details of construction were agreed on. The area around the scaffolding was roped off. As the work progressed, a single pulley wheel weighing fifteen pounds was hung from a bracket clamped to a vertical corner pipe for use by the ground man to raise a bucket containing scaffold clamps, using a rope. The pulley bracket and pulley were repositioned as the work progressed. In the meantime, of course, the scaffolding was fastened to the building at the agreed-on levels.

So far, it looked like pre-planning and front line defense was functioning perfectly. When it came time to reposition the pulley and bracket from the thirty-nine foot level, in some manner the pulley was dropped. At that moment, the ground man was directly beneath, stooping over to unfasten the snap hook from the bucket handle. Coordination between the two had failed, and a key man had missed his block. The pulley fell and struck the ground man on the back of his head, knocking him to the ground. *But,* the safety man stopped the offense. Our ground man was wearing his hard hat (we call them "safety" hats) properly, and the hat was fractured rather than the man's skull. The fact that the man's head and body gave with the impact also helped to reduce the energy absorbed by his head. The end result was that our man escaped with a minor injury instead of being killed.

Safety in Minor Repair Jobs. A majority of maintenance job time is logged by area maintenance men who perform a number of minor repair and preventive maintenance assignments in pairs or alone (Figure 10). The foreman may see them two or three times during the course of a job but largely they are on their own. With these men, training and the right attitude are of paramount importance. They are just as much on their own as the end trying to nail the football runner streaking toward the sideline.

The ability to recognize the previously unforeseen hazard during the progress of actual work has been the hardest thing for us to accomplish, it seems. This skill is so bound up in the individual personality of the man that it seems hard to lay down any hard and fast rules. We believe that eternal alertness and a questioning attitude are fundamental, and that complete familiarity with possible hazards and safety steps furnish the tools to achieve these two fundamentals. Safety imagination in the field is repeating the pre-planning analysis, consciously or unconsciously, during the actual job execution. The man asks himself, "This was the hazard we talked about; how well is the method we are using meeting that hazard? What remains to be done? What new factors have entered?"

A SPECIAL REPORT

Is Maintenance Safety Out of Hand?

FIGURE 10—Unused equipment must be placed in an orderly fashion out of the way of traffic.

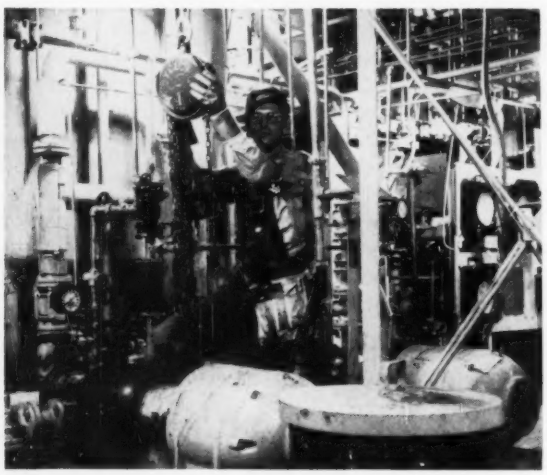


FIGURE 11—Safe minor repairs in operating buildings depend on individual performance.

About the Author

David T. Smith is the protection supervisor for the Chambers Works or E. I. du Pont de Nemours & Company, Inc., Penns Grove, New Jersey. He supervises the safety, fire protection and security groups which make up the Protection Division.

Smith

Mr. Smith holds a B.S. degree in fire protection engineering from the Illinois Institute of Technology which he received in 1930 and he has also done graduate work at the University of Delaware. His professional experience includes positions as fire protection engineer for the Kentucky Actuarial Bureau, (1930-1935), special agent for Lumberman's Mutual Insurance Company, Mansfield, Ohio (1935-1940), local and general insurance agent, Fire and Casualty Insurance, Charleston, W. Va. (1940-1942), safety and fire protection engineer with Du Pont since 1942.

Worker Attitude Reflects Management Attitude. Employe attitude generally reflects *their interpretation* of management attitude. Where management does not demonstrate its concern for safety at all times in all ways, employe reaction is that safety is not very important. The result is a lack of conviction on the part of the employe and the occurrence of unsafe practices.

Maintaining the buildings and equipment in a safe condition is the first and most basic method of management telling the employes that safety is important to management. No amount of speechmaking is convincing when the guard is left broken, the stair tread loose, or the fire door inoperative. The worker believes what he sees more than what he hears.

Because of this fact, we feel it is important to have an effective method of hearing quickly of unsafe conditions, day by day, and of doing something about them quickly, day by day. No plant ever stays in perfect condition. Prompt action is half the battle in convincing employes that management is anxious to do its part.

If a repair cannot be made promptly, we try to safeguard the hazard temporarily until it can be repaired. We may lock out, rope off, barricade or post a warning sign, *but we do something!*

Safety Repairs Get Top Priority. We have a maintenance group assigned to each operating area. A daily "confab" between the operating foreman and maintenance foreman determines priority of repairs. Items involving an immediate safety hazard are stamped "Safety" and get first priority. Others of a less immediate nature that have a safety aspect get next priority and automatically take precedence over other items after specified periods. And to insure good communication, when a job cannot be done immediately, the man reporting the item is told why, and when it will be taken care of, or why not, promptly to the best of our ability.

In summary, we believe that all injuries can be prevented, that it is our job to perform maintenance work without injury, and that the responsibility and authority lies directly with the line organization. We find that safe maintenance is not so much adding costly measures as it is efficient management. We find that maintaining our plant in a safe physical condition is essential to good employe safety attitude. And we find that the fewer injuries we have, the more we realize the real meaning of safety being in the common good.

Best regards, and hope that we have answered your questions.

/s/ David T. Smith

Sandblasting in operation. Note bonding cable (taped to sandblasting hose) extending from nozzle to tank roof. The operator's right wrist is also bonded to the same circuit with an expanded metal wrist band.

Tanks Can Be Sandblasted Safely While in Service

Tests show sandblasting sparks relatively cool - - - not hot enough to ignite flammable vapors; also, arcs will not occur if static electricity is controlled

Holly P. Bradley
Service Pipe Line Company
Tulsa

FOR MANY YEARS, sandblasting has been considered a fire hazard in the petroleum industry. Since there are, under certain conditions, very large amounts of static electricity (exceeding 30,000 volts) created by sandblasting, the assumption is well founded. However, petroleum storage tanks, including the roofs, can be sandblasted safely while the tanks are in service, provided certain safety precautions are taken. This is based on information obtained recently when tests were made in our Tulsa shops, and in actual field tests during which several tanks and their roofs were sandblasted.

Shown below are the results of some of the tests conducted, and the recommended procedure for safeguarding against the sandblast hazard.

Problem. Three specific problems studied were:

1. Are sparks created by sand striking metal? If so,

A SPECIAL REPORT

Sandblast Tanks Safely While in Service

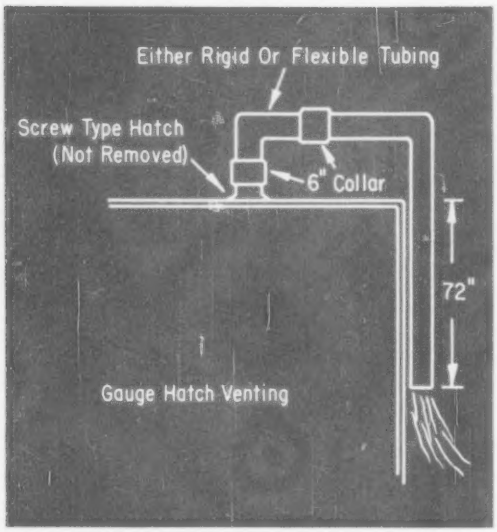


FIGURE 1—Special vent design permits tank breathing.

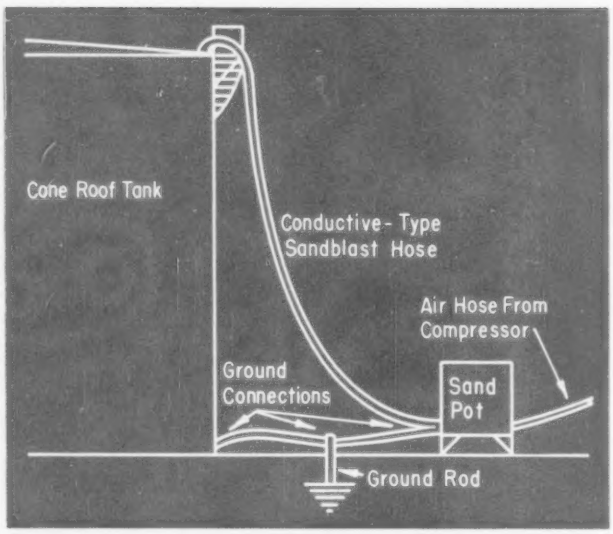


FIGURE 2—The sand pot must be grounded and a conductive type hose used.

are these sparks "hot" enough to ignite flammable vapors?

2. How much heat build-up takes place in the metal when it is being sandblasted, and is the heat build-up high enough to ignite flammable vapors?
3. What are the characteristics of static electricity involved in sandblasting operations?

Heat Tests. A simulated tank shell was formed out of a piece of 26-inch pipe 24 inches long. This shell was welded to a baseplate $\frac{3}{16}$-inch x 34-inch x 48-inch which also served as the tank bottom. Equipment used in making the tests consisted of the miniature tank; an electrostatic voltmeter, calibrated in kilovolts from zero to 30,000 volts; a pyrometer for registering the temperature of the metal; a combustible gas indicator; a small amount of gasoline; some copper tubing; some plastic tubing for connecting the gas indicator to the area inside the tank; some piano wire connected to a welder's friction lighter; and some insulated wire for use with the voltmeter and pyrometer.

Two copper tubes led into a certain area of the tank bottom as entry for gasoline, and as a suction line to the gas indicator. This system enabled us to run fuel into the tank and to measure flammable vapor mixtures throughout the entire flammable range when blasting a hole through the tank bottom at the ends of the copper tubes. By intermittently opening and closing the valve on the gasoline supply line we were able to raise and lower the flammable mixture to points above, through, and below the flammable range.

The friction lighter was anchored near the end of the copper tubes, and was operated remotely by means of the piano wire. It enabled us to start fires in the tank, and served as a check on the accuracy of the explosimeter. Thus, we proved that we were blasting in the presence of flammable vapors.

The sandblasting nozzle was secured at a fixed position inside the tank in order to cut a hole through the $\frac{3}{16}$-inch tank bottom with the blast at the end of the gasoline tube.

Temperatures of various metals tested in the series were measured by means of the pyrometer with iron constantan leads connected to the underside of specific metal being tested. In this instance it was the bottom of the tank.

In the first test, atmospheric temperature ranged from 83 to 86 degrees, and relative humidity was 55 to 63 percent. The gasoline valve was opened, allowing gasoline to enter the tank, and the vapor concentration was

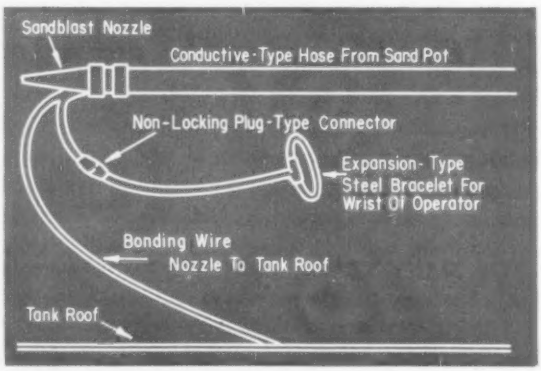


FIGURE 3—Generator, hose, nozzle and operator must be grounded to tank roof and shell.

measured by the gas indicator. Sandblasting was done with grade-4 blasting-sand, and was done continuously until a hole was cut through the tank bottom. The heat results were:

Temperature of the steel at the beginning of the test	93.2° F
After 2 minutes of cutting	122.0° F
After 4 minutes (hole completed)	109.4° F

The conditions shown above also existed in subsequent tests, and cutting was done throughout the flammable range including atmospheres too lean to burn, and too rich to burn, yet the mixture did not ignite. However, fires were readily started with the friction lighter.

Conclusion. After many tests, it was concluded that sandblasting does not create enough heat to ignite petroleum vapors.

Static Electricity. With the heat tests concluded, the next test in our series was to determine the amount and characteristics of static electricity created by sandblasting.

Static electricity was measured by the electro-static voltmeter, which was, in most of the tests, grounded to 300 feet of buried 2-inch water line. We drilled a ¼-inch hole through a dry wooden stick, and placed a ¼-inch x 1-inch steel bolt through it, and connected the voltmeter lead to the nut on the opposite side of the stick. We then sandblasted against the head of the bolt and washer, result: 30,000 volts. A lead from the electro-static voltmeter was connected to ¼-inch x 3-inch stove bolt fastened to the dry, wooden stick. When the bolt was placed in the sandblast stream, a reading of 10,000 volts was reached before the lead wire was sheared by the blast. (Note the difference of 20,000 volts from the preceding test—1-inch bolt versus 3-inch bolt.)

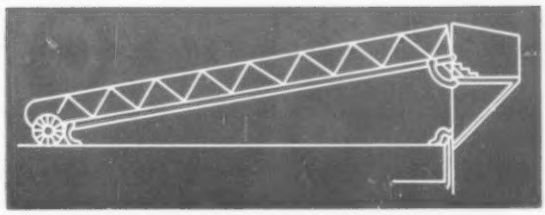
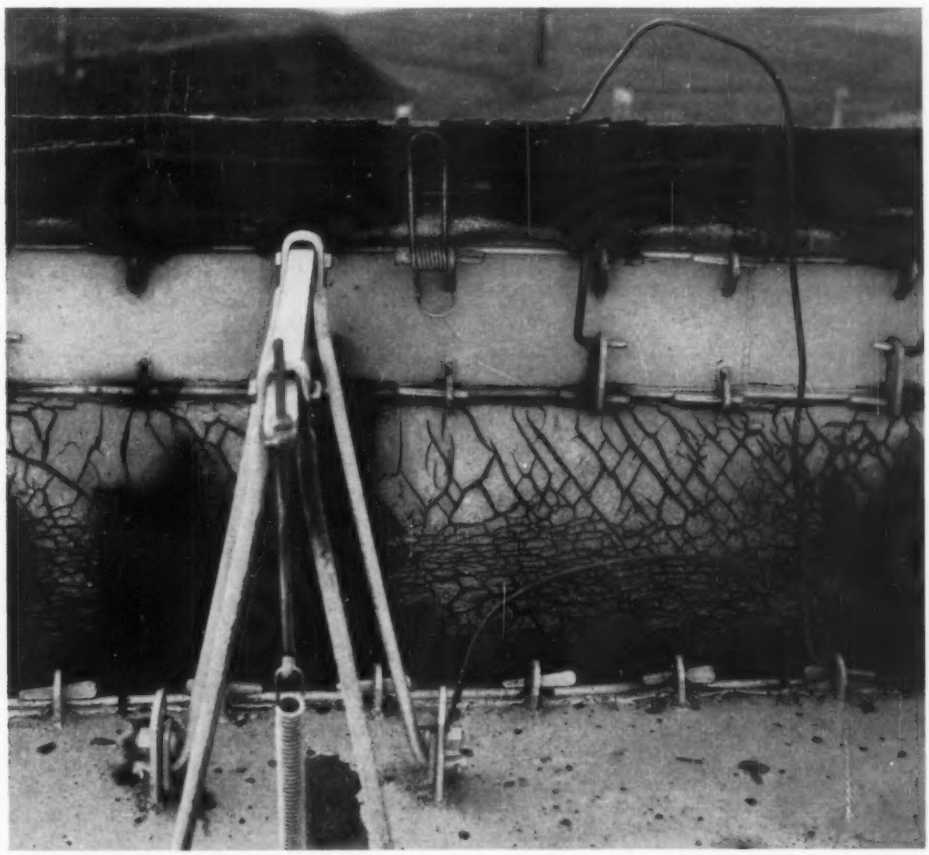


FIGURE 4—For floating roof tanks, the ladder must be grounded to the tank roof at the top and bottom.

With the same hookup as in the preceding tests, and with the lead wire attached to a ¼-inch x 6-inch bolt, 6,400 volts were recorded. It is obvious that the difference in voltage (10,000 vs 6,400) was because of the difference in size of the two pieces of metal. When we attached the voltmeter lead to a ¼-inch x 3-inch x 9-inch steel plate fastened to the wooden handle with



A bonding cable is attached to the top of the tank shell and roof. On large tanks, bonds are spaced 90 degrees apart on the circumference.

ground lead connected to the nozzle, 12,200 volts were recorded.

- Rested steel strip on the earth—no voltage recorded.
- Steel strip 3″ off the earth—16,200 volts recorded.
- We connected the lead from the voltmeter to the steel tank, and the meter ground to the hose nozzle—no voltage recorded.

Thus, we established that, by proper bonding and grounding, build-up of static electricity produced by sandblasting can be held to zero.

General Conclusions. Sandblasting creates sparks. These sparks are relatively cool, and their heat is further reduced by the effects of the blasting air.

There is some heat build-up caused by the abrasive action of sand on the tank steel. This heat increase is checked by cooling effect of the blasting air. There is no reason to suspect that the skin temperature would reach the critical temperature range—around 450 °F.

Sparks created by the sand striking metal are not hot enough to ignite flammable vapors. Also, heat build-up in the steel is no problem since the temperature build-up increases only as the size of the target metal is reduced; but even then, the highest temperature build-up (288.5 °F) was well below the ignition temperature of petroleum vapor (approximately 450 °F). The air blast exerts adequate cooling effect to control these temperatures.

Static electricity build-up is common in this type of work. In dry air this build-up will run into thousands of volts. Tests show that the major build-up occurs on items which are thoroughly insulated from ground—as when the small metal objects were secured to the dry wooden stick.

It is concluded that *sandblasting equipment, the operator, and the tank should be maintained at the same potential by bonding attachments.* If this is done, static build-up, and consequently dangerous arcs, will not occur.

About the Author

Holly P. Bradley is the safety supervisor for Service Pipe Line Company, Tulsa. He is the section head in charge of safety and fire prevention throughout the company operations.

Bradley

Mr. Bradley has engaged in full-time accident and fire prevention duties with Service for 26 years. He has been a member of the American Society of Safety Engineers for 15 years serving in all offices and numerous committees of the local chapter and as regional vice-president of the West Central Region for three terms. He is now serving on accident and fire prevention committees of the American Petroleum Institute and has recently been elected to the board of directors of the Southern Safety Conference, Inc. He is currently chairman for the Pipe Lines Petroleum Section, National Safety Council.

RECOMMENDATIONS

Cone Roofs

- The tank should be virtually full in order to reduce the dead air space as much as possible.
- Isolate the tank by closing the valves on all incoming and outgoing lines.
- The "No Smoking" rule must be observed.
- When sandblasting the roof of a cone roof tank, all fire screens must be in place, all snuffers closed, and all gage hatches closed except one which must be removed. All gage hatch covers and other tank appurtenances should be checked to see that they are not leaking. If necessary, water-soaked burlap may be placed over these openings to provide additional protection. Also, sandblasting must not be done on any tank which has corroded to the extent that leakage occurs.
- At the opening in the tank, from which the hatch is removed, a specially designed vent (see Figure 1) should be installed to permit "breathing" of the tank caused by atmospheric changes.
- The tank and the generator must be grounded to not more than 25 ohms resistance (see Figure 2), and the hose must be the conductive type.* This applies to all tanks—either cone or floating-type roofs.
- The generator, hose, nozzle, and the operator must be bonded and grounded to the tank roof and shell (see Figure 3).

Floating Roofs

- When sandblasting floating roof tanks, the tank and the roof must be bonded and grounded at the top and bottom of the ladder (see Figure 4), and from the roof to the tank shell. Also, the generator, nozzle, hose, and the operator must be bonded into the same circuit with the tank and roof.
- The tank should be virtually full in order to reduce the dead air space.
- All openings in sight-gage appurtenances, from which vapor may escape into the atmosphere, should be sealed off.
- All vents, gage hatches, etc., should be closed tightly to prevent vapors from escaping.
- Sandblasting must not be done on any floating roof of which the seal is defective.
- Adequate fire-fighting equipment should be available on the roof, and manned, ready for use at points where trouble might be expected. Persons who are assigned the task of manning the extinguishers should be entirely familiar with their use.

Every precaution should be taken to guard against falls. Chance-taking, sooner or later, results in disaster. This applies especially when working at great heights, such as the roof of cone-roof tanks, high scaffolds, etc., and when ascending or descending the floating roofs.

To prevent injury to the eyes, face, and hands, a sandblast helmet and gloves should be worn by the operator when sandblasting. ##

* For details of conductive-type hose, contact author.

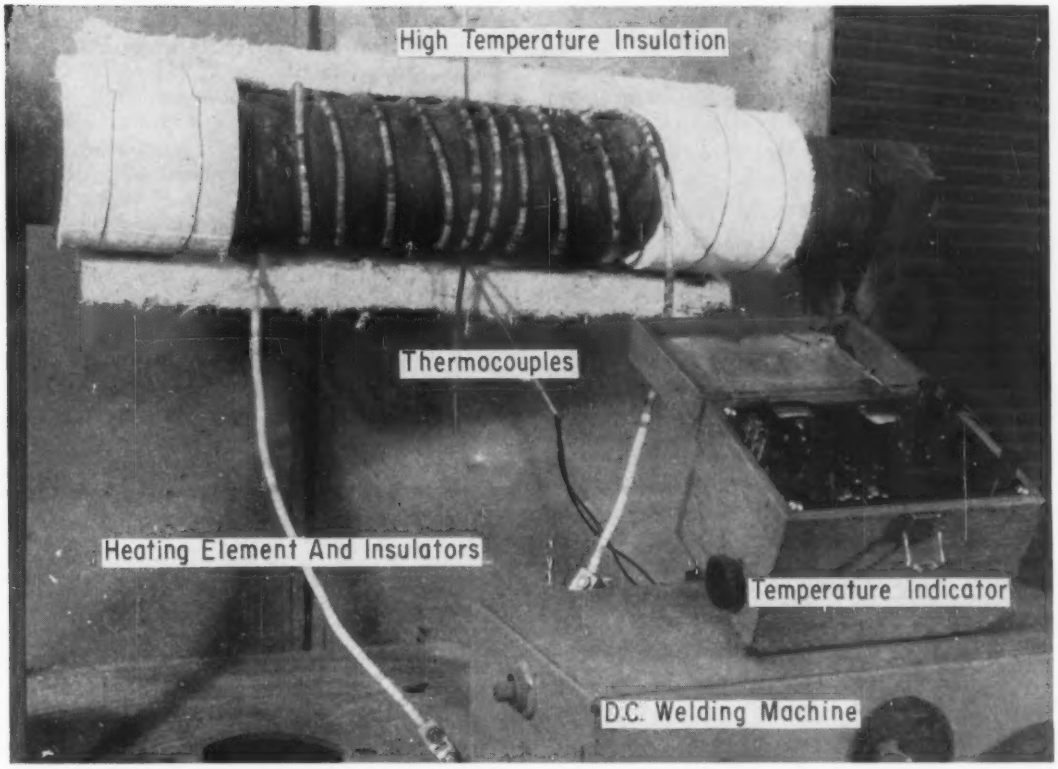


FIGURE 1—Here are the stress relieving elements attached to a section of 6-inch steel pipe.

New Look at Stress Relieving Field Welds

For accurate control of stress relief in field welds, check these points when designing electrical resistance heating elements

W. J. Keough, Imperial Oil Limited
Regina, Saskatchewan

FOR MANY YEARS the petroleum industry has been concerned with the development of alloy steels which are capable of resisting the corrosive attacks of process streams and chemicals. Chromium-molybdenum and nickel-chromium steels have become common items in the oil and chemical industry with the design of new processes demanding high temperature materials. With the increased use of these alloy steels has come the associated technical problems of proper welding procedures and the need for scientific heat treatment of weldments. When large pressure vessels require stress relief it is usually a job for the manufacturer to perform in a shop furnace but, when certain types of alloy piping are installed, the refinery maintenance department must be prepared to handle field stress relief of such welds when called upon to make repairs. One of the simplest, and most accurately controlled methods for stress relieving pipe welds is the electric resistance heating element, operating on D.C. current from a welding machine. Here are some general rules to follow when you design a heating coil

When to Stress Relieve. There are many interpretations of the term "stress relief" and there exists a cer-

tain degree of confusion with the term "anneal." To define the meaning which is intended, let us describe "Thermal Stress Relief" as "the uniform heating of a structure or portion thereof to a sufficient temperature below the critical range, to relieve the major portion of the residual stresses, followed by uniform cooling."[1] This definition limits the application of the term "stress relief" to the function of decreasing the residual stresses in a weld area and does not credit the stress relieving process for any change in the metallurgical structure of the metal being treated. In the case of ferritic alloys wherein both the relief of residual stress and a change in metallurgical structure is required, the term "postheat treatment" will be used to differentiate this function from simple stress relief.

Much experimental work has been done on the need for stress relieving in both carbon steel and the alloy steels. As experimental information is accumulated and evaluated, it is adopted by the agencies who are charged with the duty of establishing codes and design standards to ensure the safe and proper use of new construction materials. The code which must be followed is the standard accepted by the authority on design specifications in your area. For the general guide rules which we shall discuss, reference will be taken from the Code for Pressure Piping, Section 6, A.S.A. B 31.1-1955 and subsequent revisions.

Stress relief becomes necessary whenever a weld, in cooling from the molten to the solid state, is restrained in its contraction by surrounding metal to such an extent that it creates within itself and the adjacent metal, a residual stress which exceeds the safe strain limits of the material.

A familiar example of the forces at work in a weld is evident when two unrestrained pieces of steel are welded by a single pass. In this experiment the two small plates will warp as the weld metal cools and the resultant structure will be deformed from its original shape by force of the stresses which have developed in the weld. This weld has accomplished a certain degree of stress relief within itself because the surrounding parent metal has the ability to yield as the weld stresses are applied. When this same weld is performed on a section of heavy, rigidly constrained piping, however, there is no obvious distortion of the parent metal and the stresses in the weld remain locked up as a residual stress. With these random stresses inherent in the weld zone, it is unreasonable to assume that the completed structure will possess the mechanical properties of the original metal. In addition to the reduction in mechanical strength, there may also be changes in the chemical structure of the weld area which will affect the corrosion resistant properties of metal.

Further complications are encountered in the weld structure of Cr-Mo steels as well as certain of the higher alloy steels. These are referred to as the air hardening group in which the welding process promotes grain structures of extreme hardness which exhibit a pronounced susceptibility to impact failure. This classification of steels is appearing more frequently in the construction of refinery process equipment and requires careful attention to both welding procedure and heat treatment. The necessity of preheat and post heat treatment requires detailed study for each steel and rules for proper procedures cannot be generalized.

The code for Pressure Piping establishes a standard for the grades of steel that require stress relief of welded sections. This code should be consulted for the specific grade of steel that you may be concerned with, but for a general guide in recognizing the possibility of a stress relief requirement, Table I summarizes some indicators to warn the engineer that further investigations are called for.

Where and Why to Stress Relieve. What does the stress relieving process accomplish and how will it physically affect the weld? In the case of ordinary carbon steel, the theory of thermal stress relief is to raise the metal temperature to a point at which the yield strength and modulus of elasticity of the metal is greatly reduced, and to hold the welded area at this temperature for a period of time sufficient to allow the residual stresses in the weld to relieve themselves by plastic flow of the metal. The residual stresses in the weld will thereby reduce to a value somewhat below the range of the yield strength of the steel corresponding to the temperature at which the stress relief process is carried out. Maximum temperatures must not enter the Critical Range of the steel at which transformation begins, so we find the upper limit for stress relieving is usually set in the 1100°F to 1250°F range for carbon steels. In steels containing high percentages of chromium, the metallurgical structures become more complex and temperatures of 1300°F to 1450°F are required to effect satisfactory dissipation of thermal stresses.

When the maintenance engineer is faced with the problem of repairing or renewing sections of piping

Table 1—Steels Requiring Postheat Treatment

Material	Heat Treatment Required	Heat Treatment Temp. °F	Holding Time Hrs/in. Thickness	Min. Time at Temp. Hrs.
Carbon Steel	Thickness ¾ in. or greater	1100—1200	1	¾
Carbon-Mo. Steel Total Alloy 2%	Thickness ½ in. or greater	1175—1350	1	1
Cr-Mo N: Steel Total alloy 2¼%	Any Thickness	1325—1375	1	2
Cr-Mo Steel Total Alloy 10%	Any Thickness	1325—1375	1	2
High Alloy Martensitic Steel 13–15% Cr	Any Thickness	1400—1450	1	2
High Alloy Ferric Steel 16–17% Cr	Dependent Upon Service Conditions			
High Alloy Austenitic Steel 18–25% Cr 8–20% Ni	Dependent Upon Service Conditions			

TABLE 2—Electrical Design Data for Iron-Chromium-Aluminum-Cobalt Wire

Wire Diam. B & S Ga.	Wire Diam. Ins.	Resistance OHMS/Ft. @ 60 °F	Surface Area Sq. Ins./Ft.	Ft./lb.
5	0.1819	0.02526	6.858	12.42
6	0.1620	0.03185	6.107	15.67
7	0.1443	0.04015	5.440	19.75
8	0.1285	0.05063	4.844	24.90
9	0.1144	0.06388	4.313	31.41
10	0.1019	0.08051	3.842	39.61

Temp. °F	1000	1200	1400	1600
Resistance Correction Factor	1.030	1.039	1.047	1.052

which require stress relief, he invariably finds that several welds must be made in the field and therefore they must be heat treated in their final position. Unless he is in the fortunate position of having commercial stress relieving equipment at his disposal, he will be forced to devise a reliable method of heating the welded section in place. This can be done with the proper type of resistance heating elements, insulators, D.C. welding machines and temperature recorders.

Design of Heating Elements. To properly design the heating elements, there are two prime factors to consider:

- How much energy must be supplied to raise the metal temperature to the desired level.
- How much energy can be applied to the heating element without causing failure of the wire (surface load).

Example. Let us consider an actual case to demonstrate the design of one typical application. Figure 1 shows the arrangement of a heating element on a 6-inch standard weight carbon steel pipe. The resistance wire has been threaded through insulators to prevent electrical contact between the heating element and the pipe. The element is then carefully wound onto the pipe so that it covers the weld area for maximum heat intensity and is flared out on either side of the weld to provide a gradual temperature gradient. Thermocouples are attached to the pipe in the area of maximum heat intensity and are spaced along the circumference at 9-inch intervals. Thermocouple leads are attached to a portable temperature recorder so that a record of temperatures is maintained at all times. High temperature insulation is applied to the heating coil and to the adjacent areas of the pipe to reduce heat losses and provide a low temperature gradient from the heat affected zone. Electrical leads from the DC generator are connected with copper cable connectors to the resistance coil.

To estimate the heat input requirement, heat loss from the electrical coil must be calculated. If air is allowed to circulate, the greatest potential heat loss will be convection transfer to the air passing through the pipe. Therefore, it is essential to seal the open pipe ends to prevent loss by convection. Secondly, heat will dissipate from the stress relieving zone by conduction along the pipe wall which can be minimized by spreading out the heating coils as shown in Figure 1. The third source of heat loss is through the insulating material which covers the heat affected zone and which will vary according to the material and thickness of the insulation

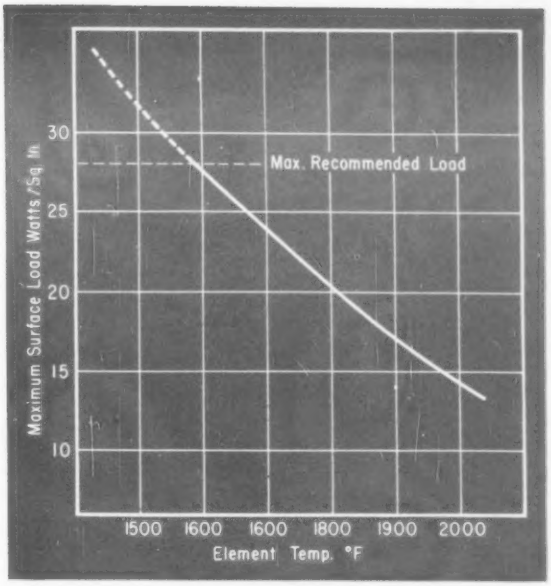


FIGURE 2—The maximum allowable surface load can be found by knowing the element temperature.

used. For the stress relieving arrangement shown in Figure 1, heat loss at 1250°F stress relieving temperature was measured at 11.5 KBTU/hr. equivalent to a required electrical input of 3360 watts/hr.

Design of the electrical heating coil requires a knowledge of the resistance of the electrical conductor and the maximum allowable surface loading for the conductor. Table 2 shows typical resistance data for Iron-Chromium-Aluminum-Cobalt heating elements and Figure 2 indicates the maximum allowable surface loads for such a conductor at various furnace temperatures. It must be borne in mind that these recommended surface loads are for well supported heating elements and since a field installation is liable to impose several forms of mechanical strain on the conductor, it is advisable to select a conservative design surface load. Loadings in the range of 40 watts per square inch have been used for short periods but usually result in failure of the element before the relieving cycle is completed. A good design maximum for a stress relieving temperature of 1200°F appears to be in the range of 25-30 watts per square inch of conductor surface.

For the heating element depicted in Figure 1, a 7 B. W. gage conductor was selected. The conductor temperature was calculated to be 1500°F for a stress relieving temperature of 1250°F.

From Table 2:

$$R = 0.04015 \times 1.049$$
$$= 0.042 \text{ Ohms/ft.}$$

Conductor surface area

$$A = 5.440 \text{ sq. in/ft.}$$

Max. allowable surface load (Figure 2) $= 28$ watts/sq. in.

Design power rating $= 3360$ watts

$$\therefore \text{Length of conductor} = \frac{3360}{28 \times 5.44} = 22 \text{ ft.}$$

$$\text{Total resistance of conductor} = 22 \times 0.042$$
$$= 0.925 \text{ ohms}$$

The required direct current in conductor to generate 3360 watts of energy

$$I^2R = 3360$$

$$I = \sqrt{\frac{3360}{0.925}}$$

$$= 60.3 \text{ amps}$$

The required voltage is

$$E = \frac{3360}{60.3}$$

$$= 55.9 \text{ volts}$$

Since the voltage and current requirements fall within the range of normal D.C. welding machine capabilities, this heating element is suitable for operation on a closed circuit across the welder terminals without danger of shorting the generator. In addition, the welding machine rheostat can be used to vary the voltage and will provide an extremely accurate means of increasing or decreasing the temperature during the stress relieving process.

The length of conductor required for the element (22 feet) will permit the stress relieved zone to be covered with nine turns of heating coil, thus distributing the heat over the weld area and eliminating any possibility of extreme temperature gradients at the boundaries of the weld area.

Temperature Gradients in Stress Relieving. Much research is being conducted in the search for data on effective stress relieving temperatures, soaking time, heating and cooling rates. The ASA Code for Pressure Piping, 1959 edition, recommends temperature and time relationships shown in Table 1 for the several grades of piping listed in the code. These temperatures have been designated to accomplish the relief of residual stress in carbon steels and to effect metallurgical changes in the alloy steels, hence the temperatures are referred to as post heat treatment rather than stress relieving temperatures.

About the Author

W. J. Keough is the mechanical superintendent of Imperial Oil Limited's Regina refinery, Saskatchewan, Canada. He supervises the refinery's Mechanical Engineering and Maintenance departments. Mr. Keough received a B.S. degree in mechanical engineering from Queen's University in 1948. His professional experience has been with Imperial since he started with the Mechanical Design Group of the Engineering Division in Sarnia after graduation. He worked for nine years at the Regina refinery as maintenance engineer and assistant technical superintendent before assuming his present position.

Keough

The rates of heating and cooling are important factors in the stress relieving process since the temperature gradients will introduce new thermal stresses in the pipe metal. For chromium steels a common practice is to heat at a maximum rate of 200°F per hour followed by controlled cooling at 200°F per hour to ambient temperature. Carbon steel may be subjected to more extreme gradients if necessary, keeping in mind that heavy wall piping should be allowed to change temperature slowly for maximum effectiveness of stress relief.

Additional Applications of Resistance Heating. The example described in this article is the simplest application of electric resistance heating wherein one element is required and the electrical energy is below 3500 watts. Many cases are encountered in refinery maintenance requiring a similar application to much larger diameter piping such as Catalytic Cracker catalyst lines. Heat input requirements increase as the pipe diameter increases and it is necessary to use multiple heating coils. However, the design procedure remains essentially as described with individual elements being connected in parallel across the welder terminals. It is advisable to design parallel circuits for a low voltage drop in the order of 50 volts and a high current flow within the range of the welding generator. A 300 ampere welder is capable of supplying 12000 watts of energy provided that the heating elements are arranged in parallel circuits.

Electrical resistance heating is also ideally suited for pre-heating steel pipe for welding. Accurate, constant preheat temperatures can be maintained with a minimum of interference in the weld area.

Design Check Points. When designing electrical resistance heating elements for stress relief operations, check the following points.

- Select suitable resistance wire for the temperatures expected.
- Design each circuit for a voltage drop of less than 60 volts. Select wire diameter which will provide an adequate length of element to cover the weld area.
- The maximum surface load should be held below 30 watts per square inch of element area at temperatures of 1200-1300°F.
- To obtain the most efficient use of each welding machine, multiple heating coils may be connected in parallel across the welder terminals.
- The heating coils must be well insulated and open ends of pipe lines must be plugged to prevent convection heat losses.
- Spare coils should be wrapped into the stress relieving area on air hardening alloy steel piping so they may be connected for quick use in case of failure of the original elements.
- Provide multiple temperature recording points in the weld area and the surrounding parent metal.

LITERATURE CITED

[1]American Standard Code for Pressure Piping ASA B 31.1—1955
[2]Kanthal Handbook 1954 Ferro Enamels Canada Limited
[3]American Standard Code for Pressure Piping ASA B 31.3—1959

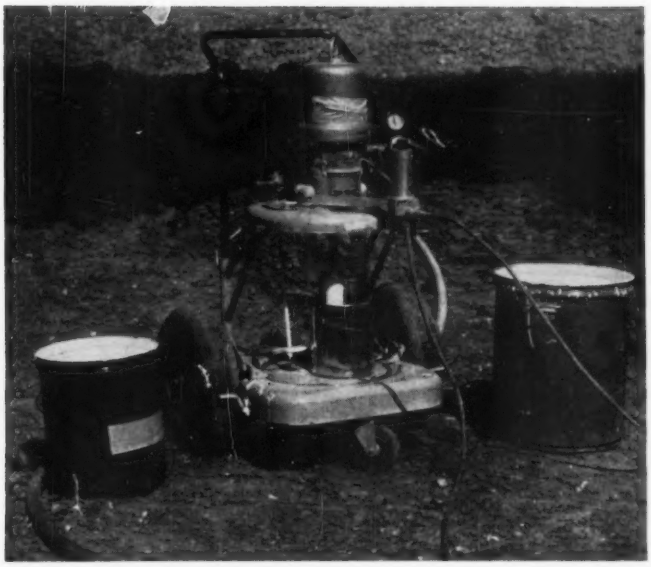


FIGURE 1—A small compressor capable of 10 cfm at 100 psi will operate a 10-gallon unit supplying two guns.

A SPECIAL REPORT
MAINTENANCE

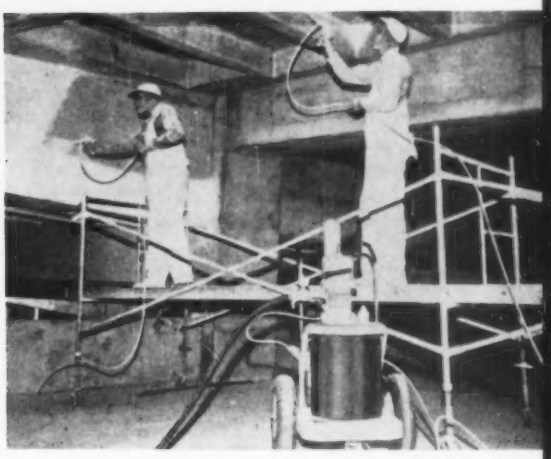


FIGURE 2—Painters can work free of respiratory protection equipment using airless spraying.

Airless Spraying Vinyl Cuts Costs 42%

Particularly well suited for vinyl base materials, airless spraying can save 35 percent on material costs and increase production as much as 100 percent

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IT HAS BEEN said that, "Vinyl resin coatings have some significant advantages but that the cost of material and proper application by customary methods exceeds our budget." Since the writer like other users must operate under the limits of a budget and must justify costs that may appear excessive, then he cannot find fault with this statement.

Let us examine the phrase, "Proper application by customary methods." Many of yesterday's methods are today's antiques; however, in the paint or protective coating field, the same old tools are being used but with newly developed techniques.

The paint brush is probably 2,000 years old. The air atomization principles or pressure pot—internal mix spray gun combination has been in use less than forty years. With man's ingenuity developing this latter method of spraying paint through a nozzle, and atomizing it by injecting a stream of high velocity air into the nozzle, we had a definite advance in the economics of painting. At the same time that spray nozzle manufacturers were improving their design and techniques, paint manufacturers were accepting the new principle by modifying their formulas to promote easier break-up of the solids through proper vehicle balancing to achieve viscosity reduction. These tools may be improved upon and probably will be used to economically apply paint for years to come.

Hydraulic Atomization is not new. The principle is as common as your garden hose spray nozzle. Restrict the nozzle and increase the fluid velocity and the stream changes to spray. About 90 years ago a British scientist, Royleigh nailed this phenomenon down in scientific terms, when after detailed studies, he stated that a *free*

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stream of liquid would break up and atomize when it exceeded a certain critical speed.

Now let us say that the discussion here will generally apply to that process which uses air operated reciprocating pumps to supply paint at high pressure, through a hose to a spray gun and atomizes the *paint by hydraulic pressure alone.* This is accomplished by forcing the paint through a small specially shaped nozzle at fluid pressures in the 1000 to 3000 psi range.

About Vinyls. The early formulations of vinyl coatings were essentially solvent solutions of PVC resin with inert pigments such as titanium dioxide and plasticizers such as coumar. They were characterized by very low solids by volume and exhibited questionable adhesion. However they had *excellent chemical resistance* over the full range of the pH scale and unusual drying qualities permitting overcoating in one to two hours. They also appeared to have little or no application problems and to have good adhesion over sandblasted surfaces. Vinyls were not generally accepted because of the low thickness requiring five or more coats for good surface protection, questionable adhesion and the tendency of some to display brittleness, cracking and peeling.

Today, a *well formulated vinyl* coating might incorporate a vinyl chloride - vinyl acetate copolymer in which the PVC constituted 87 percent or more of the resin component. The resin might be reacted with maleic acid to improve adhesion and the concentration of resin and plasticizer in the finished solution may approach 22 percent by volume and an additional 7 percent representing resistant pigments and commonly inert mineral fillers. The balance of the coatings would consist of volatile vehicles, principally ketones and aromatics.

Such materials were commonly applied by conventional air spray. Atomization of these materials by air is at best a mixed blessing. It did expedite evaporation of low boiling solvents in the solution very efficiently. However, it invites *entrapment of air* in the deposited film. Atmospheric temperature and humidity, solvent balance and spray techniques became very critical factors. The air pressure for atomization has to be *critically adjusted* to the other factors, as they may be altered.

Now by controlling all of these factors, vinyl coatings may be applied by conventional air spray with most of all the desirable features incorporated into the finished product.

Hydraulic Spray vs. Air Spray. The basic nature of air atomization as described in patents covering paint spray air nozzles, depends upon a number of *high Velocity* air streams or jets *impinging upon* a relatively slow speed liquid stream as it emerges from the fluid tip. The first jets pierce, tear apart and atomize the heavy center liquid particles, additional air jets form and envelop the atomized paint particles as they are propelled toward the target. Note here that the amount of air required to atomize and shape the spray pattern is as much as 110 times as great as the paint volume itself.

The desired end result is to get the required mil thickness of a coating *evenly and continuously* (pin-hole free) on the object intended in the most economical manner. All of the rapidly expanding volumes of atomizing air are merely a means to this end and must dissipate somewhere by *rebounding off and around* the intended target, carrying with them much of the atomized paint and solvents. This is not only wasteful of paint, but creates problems of safety and housekeeping. It requires special attention to the protection of the applicator's respiratory system and the protection of surrounding objects not to be painted.

Hydraulic Atomization, on the other hand, depends merely upon the fluid emerging from the nozzle at a *speed great enough to cause atomization.* Once atomized, there are no external forces such as atomizing air to speed the paint particles toward the intended object. The velocity energy or momentum of the minute atomized paint droplets is quickly dissipated in the relatively still air.

For sake of illustration, think for a moment of spraying paint into a box. With conventional air spray this man would easily be spraying 20 to 25 cubic feet of atomizing air into a 2-cubic-foot box. Where will this air go? Of course it will billow right back out of the box in strong eddy currents, more than likely right into the face of the operator.

This you would not see with airless spray because in this process the coating is *atomized into millions of small particles* in a fog-like pattern which floats at a relatively slow speed onto the object to be coated. There is *no high velocity air bouncing back* and creating a turbulence carrying with it much solvent and overspray. All of the coating is deposited in a wet film on the intended surface.

Economics. The objective of the owner of operating equipment such as tanks, structural steel and piping, as pertains to protective coatings should be; *to extend the life of his equipment and capital investment at the lowest possible cost, through maintenance and preservation from corrosion,* or in other words, the lowest cost per square foot/per year for the expected life of the equipment.

The purchase price of specific materials and labor is, to a degree, beyond his control but there are other ways that he can obtain the desired results by proper *selection and use of these materials and labor.* All of today's coatings and methods have several advantages and disadvantages, therefore the owner must choose the ones that will apply to his *specific environment.*

A vinyl coating will do the job in many cases more economically than any other, *if properly applied.* The most practical vinyl coating might be a *two-coat system,* however some vinyl coatings can be applied in one-coat thicknesses of *six to ten mils* and can be done with the hydraulic spray equipment *at a reduced cost* (see Table 1).

The broadening commercial acceptance of the airless spray idea is not the result of any spectacular break-

thru, but rather a gradual evolution of the process made possible by new construction materials—tungsten carbides, nitralloy, teflon and production techniques such as frequency, resonant impact grinding and micro-finishing processes. These things along with a straight forward design approach, have made the hydraulic spray application of paint economically feasible today.

Advantages of Airless Spray. Material savings **through the reduction of overspray** normally will be in the 25 percent to 35 percent range but under some conditions have been known to go to near 100 percent. For instance, we have sprayed vinyls in 30 to 35 mile per hour wind with no noticeable loss of material, yet with air-spray in the same conditions the loss of material was near 50 percent. This was calculated in this manner: one gallon of 100 percent solids by volume will coat 1604 square feet of surface one mil thick, multiply 1604 by the percent of solids and you have the theoretical square foot coverage per gallon for one mil of dry film thickness. Overspray and bounce-back are the greatest problems with conventional air spray today.

Less solvents are needed with airless spray. Paint and equipment manufacturers again have worked together and vinyl coatings are now available which have *less solvents* and *more solids* which are only sprayable in the *hydraulic spray.* Thus we find that one of the biggest advantages of airless spray is the ability to break up and atomize heavier viscosity materials. In most cases, conventional air spray coatings must be reduced with solvents and thinners to viscosities of approximately 50 centipoises in order to obtain proper atomization. All of these thinners and solvents must be evaporated out of the finished film. On the other hand, most coatings in the 200 to 400 centipoise viscosity range (in some cases as high as 2000 centipoise) are readily applied with airless spray. This means that the solids, the pigments, and fillers and bonding plasticizers, which are the only components desired in the finished coating, constitute the *major part of the liquid* being sprayed.

The advent of hydraulic atomization dictated, in some cases radical modifications in the formulation of vinyls, and much of the technology is still shrouded in secrecy. This much is known. The *viscosity* of the material has been *increased* substantially. Materials are available today that approach the consistency of mayonnaise. The resin component is *still essentially a copolymer of PVC and PVA;* however, a significant amount of acrylic resin or something of the same nature has been added to increase the solids content. Formulators report that the *ratio of resin and plasticizers to pigment* is exactly the *same* in airless spray formulations as in those designed for conventional applications. This is significant since it indicates that the mil thickness obtained in the airless spray has not been achieved through the addition of inert silicates, mica, talc, asbestos, or other inert fillers.

Material is saved through handling. The air mixer and pump are set right down into the bottom of the shipping container without any pouring, mixing, box-

TABLE 1—Cost Comparison Spray Painter vs. Airless Method (Tank #9007 - 10,700 Sq. Ft.)

AIR SPRAY COSTS—1952

Labor Cost @ $3.10/hr.

Handclean	@ .30	$3,210
Brush Prime	@ .15	$1,605
10,700 sq. ft.	@ .45	$4,815

Material Cost

Two coats of Vinyl @ 3 mil

Material	@ .068	
Air Spray	@ .042	
10,700 sq. ft.	@ .11	= $1,177

Total Cost

@ .56 = $5,992

AIR SPRAY COSTS—1959

Labor Cost @ $4.30/hr.

Handclean	@ .41	$4,387
Brush Prime	@ .19	$2,033
10,700 sq. ft.	@ .60	$6,420

Material Cost

Two coats of Vinyl @ 3 mil

Material	@ .075	
Air Spray	@ .055	
10,700 sq. ft.	@ .13	= $1,391

Total Cost

@ .73 = $7,811

AIRLESS SPRAY COSTS—1959

Labor Cost @ $4.30/hr.

S. B.	= .16	
Sand	= .08	
Clean	= .06	
Total	@ .30	= $3,210
Zinc	= .12	
Labor	= .06	
Total	@ .18	= $1,926
		$5,136

Airless Spray 1 Coat 6 Mils

Vinyl	= .10	
Airless Spray	= .03	
Total	@ .13	= $1,391

Total Costs

@ .61 = $6,527

Note: Vinyl in 1952.....$6.00
Vinyl in 1959.....$6.65

ing or thinning. All mixing is accomplished within the airless spray unit thus eliminating any spillage or residue of material left in the container when it is poured into a pressure pot.

Cost of labor may be reduced as much as 50 percent. We have said that the owner may not have much control of the cost per hour that he is required to pay the skilled applicator but he still may get the job done easily for *half of the conventional cost.* Consider these facts: Because of reduced solvent content, higher viscosity, hydraulic atomization and other factors, airless sprayed vinyls may be applied in *one coat* to a mil thickness that would require a minimum of *three coats* by air spray to attain. Although the fluid orifice is smaller in airless spray, the high fluid pressure results in more actual fluid delivery, permitting the operator to move faster. One spray painter accustomed to applying 20 gallons of paint per day will, with ease, apply 40 gallons. Also the downtime for the spray operator is greatly reduced due to the elimination of the mixing, pouring, boxing, stirring of paint, and the unclamping and reclamping of the pressure pot each time of refilling. The airless spray equipment is throughly cleaned in much less time at the end of the day than is the pressure pot, hose and gun. Labor savings may be further reduced due to enhancement of sprayman's comfort. With the great reduction in overspray, the reduced weight in the lighter gun and single hose, the spray painter may produce a higher quantity and quality of work.

Control is in the hands of the foreman and inspector. One air regulator to pump is the only regulation necessary. The spray gun is nothing more than an on-off fluid control valve. The spray pattern and correct atomization of material is controlled by the orifice selected for the specific job instead of the individual eccentricities of the spray painter.

Vinyl spraying technique with the pressure pot is extremely *critical.* The gun must be held 6 to 8 inches from the work, no more, no less, and must be held at all times at an exact 90 degree angle for maximum results. Pressure pots may have to be placed on the same level with the operator, otherwise the pressure variation from pot to gun must be guessed at and will change each time the painter changes position. These are *not near as critical with airless spray.* A 376 foot tower was successfully airless sprayed in Houston with the pumping unit on the ground. The pressure reserve potential eliminates the need for carrying the paint on the stage.

The airless spray unit requires only 8 to 10 percent of the volume of air required by the air pressure pot units. This constitutes a savings. Sufficient air to operate a 10 gallon unit with two guns can be supplied by a small air compressor such as 1½ hp capable of 10 cfm at 100 psi. This two-gun unit pump would use about 3 cfm as compared with 30 to 40 cfm with conventional spray. Of course the air driven agitator in either unit would only pull an average of 3 cfm.

The airless does *not* inject the *air supply contaminants,* such as oil, moisture or other entrainment *into the paint film.*

Disadvantages of Airless Spray. Among the factors that must be weighed against the advantages, is the *high initial cost* of the equipment. A portable unit complete with two guns and two 50 foot lengths of hose costs about $1,500. In the early models, the predominant pump ratio was 20 to 1. Some materials required pressures of up to 2500 psi. Air supply had to be kicked up to 125 to 130 psi. Later models have 30 to 1 ratio, requiring pressures of 80 to 100 psi. As with any new product there are a few *mechanical "bugs"* in the systems offered. Many of these are now being, and others will be, improved upon.

A degree of *personnel training* is obviously needed as with any new device. However, this *is not* as *tedious* or *technical* as it might seem. In the two years that the writer has been using the hydraulic spray system, he has assisted in the training of about 27 skilled spray painters on the payroll of his company. The training of each consisted of from one to three weeks of just using the equipment. All of them are rated top airless spray operators and are now very prejudiced in favor of the airless spray system.

Over-all Savings. If we properly use the airless spray techniques that are available today we can apply a vinyl coating for 42 percent less than any other method of application but it has to be worked at by the owner, manufacturers of spray equipment and coating materials and applicators. Each must want to save that 40 percent.

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DuPuy

Rate Exchangers This Computer Way

Digital computers can take the tedious, repetitive labor out of heat exchanger design and give you a great deal more time for design evaluation. You will want to check over the computer program proposed here

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A FLEXIBLE COMPUTER PROGRAM will allow the process designer more time to analyze the effect of variables in exchanger design. Here is such a program for a digital computer which will handle:

- Convection heat transfer on both tube and shell sides of a heat exchanger.
- Condensation on shell side with convection heat transfer on the tube side.

The program is suitable for plain and low-finned tubing used in fixed tube sheet bundles and, by modification, in U-bundles. The computer uses a typewriter and punched paper tape for input and output. The design procedure for the program is:

1. List physical data of fluids and design limitations on a data type-in form.
2. Load program tape on computer.
3. Type in data.
4. Place a data type-out form on typewriter drum and begin computing.
5. Receive design data typed-out by computer.
6. Evaluate design.

Limitations. The program is limited to the following dimensions and physical arrangements:

- **Tubes:** ¾ and 1-inch outside diameter (integral low-

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How a Computer Program Helps With Exchanger Design

The design and layout of most shell and tube units require a sizeable number of repetitive trial and error calculations. A designer assumes a unit and calculates its performance to determine if it is satisfactory. This requires the following assumptions:

- U_o
- Cooling or heating flow rate
- Tube length
- Number of tube lengths
- Shell baffle pitch
- Shell baffle cut

If the heat transfer capacity is too small or excessively large, or if the tube side or shell side pressure drop is too high; one or more of these assumptions must be changed. This change is based on the designer's experience, intuition, or guess.

The complete design of an average shell and tube unit usually requires several man-hours or several man-days. For a new medium-sized chemical plant the process design calculations of the heat exchangers often require 1,000 man-hours.

Small single exchangers require 8 to 15 man-hours, average process exchangers require 10 to 50 man-hours, and involved units may require 75 to 200 man-hours when calculated using a slide rule. With electronic computing equipment, the time of actual design calculations can be cut to 20 to 40 minutes with an additional 1 to 2 hours required for arranging physical data, entering into the computer, and review and preparation of final specifications and summary forms. This brings a specific design down from say 20 to 50 hours by slide rule methods to 2½ hours with the computer.

In addition to the time saved on design, the computer allows several re-evaluations at alternate operating conditions. This is perhaps the most valuable part of the computer's contribution into the design effort. It promotes an understanding of the conditions of the problems in its operating environment as contrasted to a single-shot design to get a design to fit one set of conditions. Time is available for thinking as compared to the same or more time in "grinding" out a solution. The evaluation of existing units for revised applications is an important part of most chemical plant design engineering work. With a computer the limitations of the unit in the service, or the limits to be expected in performance can be identified.
Experience for about one year's operations with this computer program indicates:

New Designs		
No. Units	No. Alternates Studied	Existing Unit Evaluations
350	500	225

finned tubes with 16 or 19 fins/inch and plain tubes), for fixed tube sheet units, and with modification can handle U-tube designs.

- **Tube Spacing:** 15/16-inch triangular, 1-inch and 1¼-inch triangular and square pitch.
- **Shell I.D.** (Standard T.E.M.A.): 8, 10, 12, 13.25, 15.25, 17.25, 19.25, 21.25, 23.25, 25, 27, 29, 31, 33, 35, and 37 inches.
- **Baffle Cuts:** 20%, 25%, 33.3%, 40%, and 50% for convection heat transfer.
- **Number of Tube Passes:** 1, 2, 3, 4, 5, 6, 7, or 8
  A modifying command will cause the program to use only an even number or only an odd number of tube passes.
- **Number of Shell Passes:** 1

Logic Pattern. A brief description of the logic pattern is given as follows (see Figure 1):

- Beginning with an 8-inch diameter shell, shell sizes are incremented until U_o required is less than U_o maximum set by designer. Tube counts are calculated for each case by a correlation developed for this program.
- The following are calculated and evaluated by the limits set by the designer:
  a. Tube side velocity
  b. Temperature difference correction factor
  c. Tube side pressure drop
- Film coefficients and U_o available are calculated. If U_o available is larger than U_o required, program proceeds. If not, the heat exchanger design parameters are incremented in the following order until U_o available is greater than U_o required:
  a. Number of tube passes
  b. Tube sizes and spacing
  c. Shell size
  d. Number of shells in parallel or series
- Area safety factor is calculated and evaluated by the limit set by the designer on the minimum area safety factor.
- Design typed out.
- If designs with different tube lengths are to be evaluated, program increments tube length, repeats from the beginning, and types out design. Designer evaluates designs with the different tube lengths.

By tracing the path of the diagrams it may be seen that the first exchanger to reach the type-out stage is the smallest shell with the least number of tube passes and shell baffles that will meet all the required limits of performance.

EXAMPLES OF WHAT THE COMPUTER TELLS

The examples presented here are designed to show the versatility and value to the design in the interpretation of actual performance factors in exchanger selection. These are not the only results for a given situation.

Convection Heat Transfer. A fixed tube sheet shell and tube heat exchanger is to be designed using the data shown in Table 1. Heat duty is 1.6545×16^6 Btu-hr. Tube sheet thickness is assumed to be two inches. Design with 14-gage tubes 8, 12, and 16 feet in length. Since the fluid density indicates the fluid is a gas, assume U_o maximum is 100. (For a liquid on both sides, assume U_o maximum is 300.) Low-finned tubes are to be used.

In response to data input commands, shown in addresses 828, 829, and 830 of Figure 2, three designs were computed and typed out with 8, 12, and 16-foot tubes. This type-out sheet is shown in Figure 3. An examination reveals the following:

Approximately the same surface areas are required for the 8- and 12-foot units; i.e., 1297.9 and 1350.5 sq. ft respectively. The 16-foot unit requires considerably greater surface area, 1813.5 sq.ft. Since the surface area is often the controlling factor in the purchase price, the 16-foot design would probably be eliminated. Since the 8- and 12-foot units would cost approximately the same, the selection can be based on other factors such as design layout, duplication of existing units, etc.

The maximum shell baffle pitch was set at 2.0 feet by data input. Since the shell baffle pitch was approximately 2 feet in all three designs, it may be seen that the $\triangle P_s$ Max. of 4.0 psi was a controlling parameter. Also, each $\triangle P_s$ was between 3 and 4 psi. Since the 8-foot design was the smallest unit and the $\triangle P_s$ Max. is the controlling variable, the $\triangle P_s$ Max. will be changed by a single command and the results will be evaluated. The values for $\triangle P_s$ Max. will be 3, 5, and 7 psi.

Type-outs of alternate designs of the 8-foot unit were obtained as shown in Figure 4. From these type-outs it may be concluded that if the $\triangle P_s$ Max. was increased from 4 to 7.5 psi, the unit size could not be decreased. If the $\triangle P_s$ Max. was decreased to 3 psi, a 23.25-inch I.D. unit with 1600 sq. ft. would be required.

Note such items as the shell baffle cut, shell side film coefficient, shell side pressure drops, and area safety factor for $\triangle P_s$ Max. of 5.0 and 7.5 psi. A 20% and 25% baffle cut was used for 7.5 and 5.0 psi $\triangle P_s$, respectively. The $\triangle P_c$ is almost the same, 0.71 and 0.77 psi; $\triangle P_b$ is 2.36 and 4.46 psi; and $\triangle P_s$ is 3.07 and 5.23 psi. Since h_o is dependent on the mean of G_b and G_c, h_o for 20% baffle cut is higher than h_o for 25% baffle cut, 89.9 compared to 81.7. The tube side velocity, h_i,

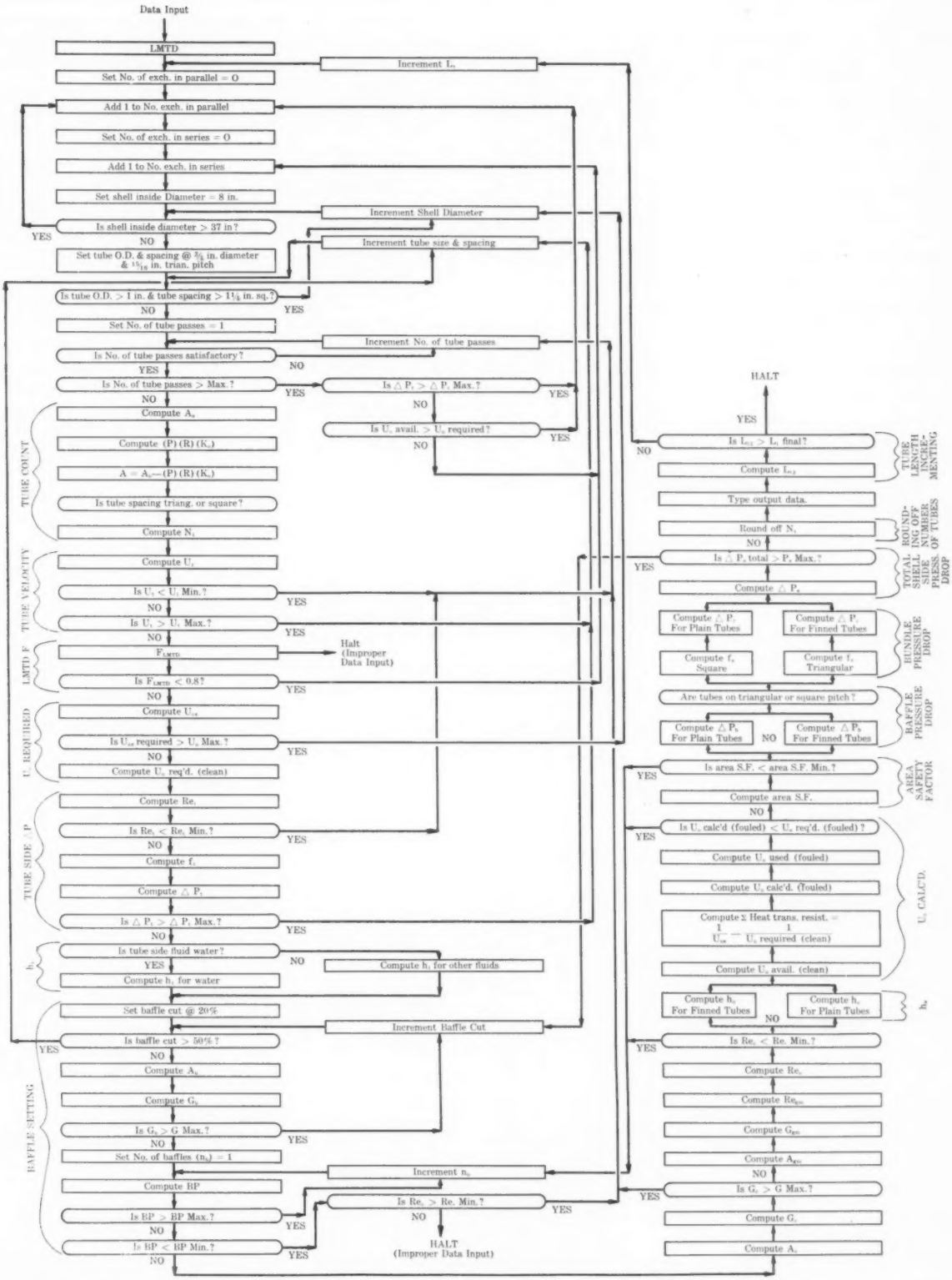
Data Input
LMTD
Increment L_t
Set No. of exch. in parallel = 0
Add 1 to No. exch. in parallel
Set No. of exch. in series = 0
Add 1 to No. exch. in series
Set shell inside Diameter = 8 in.
Increment Shell Diameter
Is shell inside diameter > 37 in.?
YES
NO
Increment tube size & spacing
Set tube O.D. & spacing @ 3/4 in. diameter & 15/16 in. trian. pitch
Is tube O.D. > 1 in. & tube spacing > 1 1/4 in. sq.?
Set No. of tube passes = 1
Increment No. of tube passes
Is No. of tube passes satisfactory?
Is No. of tube passes > Max.?
Is $\triangle P_t > \triangle P_t$ Max.?
Is U_c avail. > U_c required?
HALT
Is $L_{t+1} > L_t$ final?
Compute L_{t+1}
Type output data.
Round off N_t
Is $\triangle P_t$ total > P_t Max.?
Compute $\triangle P_t$
Compute $\triangle P_t$ For Plain Tubes
Compute $\triangle P_t$ For Finned Tubes
Compute f_t Square
Compute f_t Triangular
Are tubes on triangular or square pitch?
Compute $\triangle P_s$ For Plain Tubes
Compute $\triangle P_s$ For Finned Tubes
Is area S.F. < area S.F. Min.?
Compute area S.F.
Is U_c calc'd (fouled) < U_c req'd. (fouled)?
Compute U_c used (fouled)
Compute U_c calc'd. (fouled)
Compute Σ Heat trans. resist. = $\frac{1}{U_{c_{calc}}} - \frac{1}{U_c \text{ required (clean)}}$
Compute U_c avail. (clean)
Compute h_t For Finned Tubes
Compute h_t For Plain Tubes
Is Re_t < Re. Min.?
Compute Re_t
Compute Re_{sc}
Compute G_{sc}
Compute A_{sc}
Is $G_s > G$ Max.?
Compute G_s
Compute A_s
Is Re_t > Re. Min.?
HALT (Improper Data Input)
Compute A_{t_c}
Compute (P) (R) (K_c)
$A = A_{t_c} - (P)(R)(K_c)$
Is tube spacing triang. or square?
Compute N_t
Compute U_t
Is $U_t < U_t$ Min.?
Is $U_t > U_t$ Max.?
F_{LMTD}
Halt (Improper Data Input)
Is $F_{LMTD} < 0.8$?
Compute U_{c_a}
Is U_{c_a} required > U_c Max.?
Compute U_c req'd. (clean)
Compute Re_t
Is $Re_t < Re_t$ Min.?
Compute f_t
Compute $\triangle P_t$
Is $\triangle P_t > \triangle P_t$ Max.?
Is tube side fluid water?
Compute h_t for other fluids
Compute h_t for water
Set baffle cut @ 20%
Increment Baffle Cut
Is baffle cut > 50%?
Compute A_s
Compute G_s
Is $G_s > G$ Max.?
Set No. of baffles (n_b) = 1
Increment n_b
Compute BP
Is BP > BP Max.?
Is BP < BP Min.?
TUBE COUNT
TUBE VELOCITY
LMTD F
U REQUIRED
TUBE SIDE ΔP
h_t
BAFFLE SETTING
TUBE LENGTH INCREMENTING
ROUNDING OFF NUMBER OF TUBES
TOTAL SHELL SIDE PRESS. DROP
BUNDLE PRESSURE DROP
BAFFLE PRESSURE DROP
AREA SAFETY FACTOR
U_c CALC'D.
h_t

FIGURE 1—Here is a step by step program of the way a tube and shell exchanger can be designed by using a digital computer.

and U_o used are identical for the 5.0 and 7.5 psi designs. The larger area safety factor for the 7.5 design is due entirely to the higher h_o causing the higher U_o Calc'd., 44.59 compared to 42.48. The larger area safety factor of 22.79% for the 3 psi design was due to the $\triangle P_s$ Max. causing a larger unit than necessary for the heat transfer.

Each unit has four tube passes per shell. While this was necessary for heat transfer with the 5.0 psi design, it was caused by the U_t Min. with the 3.0 psi and 7.5 psi designs. Reason: U_t Min. is 3.0 ft./sec. Number of tube passes allowable is 1, 2, 4, 6, and 8 which are tried progressively in that order. With each unit it may be seen that the tube side velocity would be less than 3 ft./sec. for 2 tube passes/shell. If four tube passes are considered undesirable, two alternates are now seen as being possible:

a. Increase water flow rate.

b. Decrease U_t Min.

A comparison of calculated and actual tube counts is given in Table 2.

Total Condenser (Plain Tubes). A fixed tube sheet shell and tube condenser with plain tubes is to be designed useing the data shown in Table 3. Heat duty is 2.99×10^6 Btu/hr. Tube sheet thickness is assumed to be 2 inches. Design with 14-Ga. tubes 8- and 12-feet long. Assume U_o Max. is 400.

The computer type-out sheets are not shown for this example. The results, however, show the total areas for the 8- and 12-foot units are approximately the same, 504 and 525 sq. ft. Thus, the selection can be based on design layout, etc.

The shell baffle cuts typed are computed based on the edge of the baffle being on the center line of the second row above the shell center line; thus, a larger shell has a larger baffle cut (per cent of diameter), 41.2% and 39.1% baffle cuts for 21.25- and 17.25-inch I.D. shells respectively.

The baffle window calculated has no effect on the heat transfer computed since the tube loading method is used. While a $\triangle P$ is calculated, it is practically always insignificantly small. The baffles are considered only as tube supports. They are included in the computations in order to possibly save time later in the mechanical design layout of the shell bundle.

A comparison of calculated and actual tube counts is given in Table 4.

Computer Language Looks Like This

The program uses numbers in floating decimal form for both data input and data type-out. Examples:

Actual Number	Equivalent Floating Decimal Number
100.0	53.10000
10.5	52.10500
0.007856	48.78560
7,589,600.0	57.75896
0.25	50.25000

This system is represented in the type-out of data and should be referred to, in order to translate into an actual decimal figure.

Heat Exchanger Program Data—Type In

Item	Address	Data	On Tape
W'_s, Avg. Vap., Lbs/Hr	797	**55.34600**	
W_s, Total Fluid, Lbs/Hr.	798	**55.34600**	
W_t, Total Fluid, Lbs/Hr.	799	**56.11030**	
T_1, Hot Fluid Inlet, °F	800	**53.16300**	
T_2, Hot Fluid Exit, °F	801	**53.10400**	
t_1, Cold Fluid Inlet, °F	802	**52.85000**	
t_2, Cold Fluid Exit, °F	803	**53.10000**	
Q, Btu/Hr.	804	**57.16545**	
ρ_t, Lbs/Cu. Ft.	*805	.....	52.62400
μ_t, Lbs/Ft-Hr.	*806	.....	51.16600
μ_{tw}, Lbs/Ft-Hr. @ Wall	*807	.....	51.16600
K_t, Btu/(Hr.) (Ft^2) (°F/FT)	*808	.....	50.36250
Cp_t, Btu/Lb °F	*809	.....	51.10000
Open	810	.....	
Open	811	.....	
Sp. Gr_t. [H_2O (LIQ) = 1.0]	*812	.....	51.10000
U_t Min. F/S	*813	.....	51.30000
K_M, Tube Metal Therm. Cond., Btu/(Hr) (FT^2) (°F/FT)	**814	.....	52.64000
L_W, Wall Thickness, Ft.	815	.....	48.69200
L_{FW}, Fin Thickness, Ft.	816	.....	48.10000
Tube Sheet Thickness, Ft.	817	.....	50.16670
(+ Is H_2O On Tube Side −Not H_2O On Tube Side)	*818	.....	51.10000
ρ_s, Lbs/Cu. Ft.	819	**50.41000**	
μ_s, Lbs/Ft-Hr.	820	**49.37000**	
μ_{ws}, Lbs/Ft-Hr. @ Wall	821	**49.37000**	
K_s, Btu/(Hr.) (FT^2) (°F/FT)T	822	**49.21000**	
K_{ws}, Btu/Hr. (FT) (°F/FT) @ Wall	823	**49.21000**	
Open	824	.....	
Open	825	.....	
Sp. Gr.s. [H_2O (Liq) = 1.0]	826	**48.65800**	
Cp_s, Btu/Lb °F Hr.	827	**50.81050**	
L_I, Initial Tube Length, Ft.	828	**52.12000**	
L_F, Final Tube Length, Ft.	829	**52.20000**	
$\triangle L$, Incremental Tube Length, Ft.	830	**51.40000**	
U_o Max., Max Allowable U_o, Btu/Hr °F FT^2	831	**53.10000**	
$\triangle P_t$, Max. Total Allowable $\triangle p_T$, PSI	832	**52.10000**	
$\triangle P_s$, Max. Total Allowable $\triangle P_s$, PSI	833	**51.40000**	
Tube Gage	617-8 & 626-7	**14 Ga.**	14 Ga.
R_I, Tube Side Resistance	854	.....	48.15000
R_o, Shell Side Resistance	855	.....	48.15000
Limits			
Minimum LMTD F	663	.....	0.8
Minimum Reynolds Number (Shell & Tube Side)	664	.....	2300
Maximum Baffle Pitch, Ft.	670	.....	2.0 Ft.
Maximum Shell Side Mass Rate	686	.....	1.0×10^6
Minimum Baffle Pitch, Ft.	687	.....	0.25 Ft.
Minimum Area Safety Factor	786	.....	5.0
Maximum U_T, F/S	789	.....	8.5
Maximum Number Tube Passes	793	.....	8.0

* Data For H_2O On Tube Side @ 80 to 120 °F is on Tape. ** Admiralty.

FIGURE 2—Physical data of fluids and design limitations are listed on a data type-in form.

HOW SOME OF THE EQUATIONS WERE DEVELOPED

Convection Heat Transfer (Shell Side). Much of the data reported in the literature for turbulent-flow heat transfer makes use of the Sieder and Tate type of correlation:

$$\frac{h_o D_e}{K} = C\left(\frac{D_e G_{gm}}{\mu}\right)^{0.6}\left(\frac{C_p\mu}{K}\right)^{0.333}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

C = Numerical constant depends on the unit

The usual procedure is to plot the Reynolds number $\left(\frac{D_e G_{gm}}{\mu}\right)$ versus the remainder of the equation which is termed as the J_H factor:

$$J_H = \left(\frac{h_o D_e}{K}\right)\left(\frac{C_p\mu}{K}\right)^{-0.333}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$$

In this correlation, the fluid thermal conductivity, K, must be obtained at the bulk temperature to obtain h_o. However, the amount of conductivity data available for fluids, particularly gases, is relatively small. When available, it is often of questionable accuracy. The Sieder and Tate correlation can be transposed as follows:

$$\frac{h'_o D_e}{K} = C\left(\frac{D_e G_{gm}}{\mu}\right)^{0.6}\left(\frac{C_p\mu}{K}\right)^{0.333}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Heat Exchanger Program—Type Out

Item		TRIALS I	II	III
Tube Length (Ft.)	(835)	51.80000	52.12000	52.16000
No. of Shells in Parallel	(836)	51.10000	51.10000	51.10000
No. of Shells in Series	(837)	51.10000	51.10000	51.10000
Exposed Area (Ft^2/Shell) (Outside)	(838)	54.12979	54.13505	54.18135
Shell I.D. (Inches)	(839)	52.21250	52.17250	52.17250
No. of Tubes/Shell (N_t)	(840)	53.34100	53.23300	53.23300
Tube O.D. (Inches)	(841)	50.73900	50.73900	50.73900
Tube Pitch (Inches)	(842)	50.93750	50.93750	50.93750
Tube Spacing (Tri. or Sq.)	(843)	51.10800	51.10800	51.10800
Tube Passes/Shell	(844)	51.40000	51.20000	51.20000
Tube Velocity (Ft./Sec)	(845)	51.50322	51.36798	51.36798
Shell Baffle Pitch (Ft.)	(846)	51.19167	51.19444	51.19583
Shell Baffle Cut (1% of Dia.)	(847)	52.25000	52.40000	52.50000
ΔP_t (Total No. of Shells) (PSI)	(848)	51.63100	51.22799	51.27949
ΔP_b/Shell (PSI)	(849)	51.23556	51.26506	51.20560
ΔP_e/Shell (PSI)	(850)	50.71483	50.95128	50.99392
ΔP_s (Total No. of Shells) (PSI)	(851)	51.30705	51.36918	51.30500
Q/Shell (Btu/Hr.)	(852)	57.16545	57.16545	57.16545
Fin Efficiency (ef)	(853)	50.97000	50.97000	50.97000
Tube Side Fouling Factor (ri)	(854)	48.15000	48.15000	48.15000
Shell Side Fouling Factor (ro)	(855)	48.15000	48.15000	48.15000
Tube Wall Resistance (rm)	(856)	47.38148	47.38148	47.38148
Tube Side Film COEF (Btu/Hr. °F FT^2)	(857)	54.12887	54.10032	54.10032
Shell Side Film COEF (Btu/Hr. °F FT^2)	(858)	52.81724	52.81766	52.74676
Uo Calc'd. (Fouled) (Btu/Hr. °F FT^2)	(859)	52.42480	52.40903	52.39048
Uo Used (Fouled) (Btu/Hr. °F FT^2)	(860)	52.40030	52.38471	52.28649
LMTD (°F) (Uncorrected)	(861)	52.36707	52.36707	52.36707
LMTD F	(862)	50.86757	50.86757	50.86757
Area Safety Factor $\left(\frac{U_o \text{ calc-1}}{U_o \text{ used}}\right)$ (100)	(863)	51.61216	51.63206	52.36300

FIGURE 3—The type-out form shows results for three different lengths of tubing.

Heat Exchanger Program—Type Out

Item		ΔP_s Max. 3.0	5.0	7.5
Tube Length (Ft.)	(835)	51.80000	51.80000	51.80000
No. of Shells in Parallel	(836)	51.10000	51.10000	51.10000
No. of Shells in Series	(837)	51.10000	51.10000	51.10000
Exposed Area (Ft^2/Shell) (Outside)	(838)	54.16000	54.12979	54.12979
Shell I.D. (Inches)	(839)	52.23250*	52.21250*	52.21250*
No. of Tubes/Shell (N_t)	(840)	53.42100	53.34100	53.34100
Tube O.D. (Inches)	(841)	50.73900	50.73900	50.73900
Tube Pitch (Inches)	(842)	50.93750	50.93750	50.93750
Tube Spacing (Tri. or Sq.)	(843)	51.10800	51.10800	51.10800
Tube Passes/Shell	(844)	51.40000	51.40000	51.40000
Tube Velocity (Ft/Sec)	(845)	51.40819	51.50322	51.50322
Shell Baffle Pitch (Ft.)	(846)	51.19167	51.19167	51.19167
Shell Baffle Cut (% of Dia.)	(847)	52.25000	52.25000*	52.20000*
ΔP_t (Total No. of Shells) (PSI)	(848)	51.42777	51.63100	51.63100
ΔP_b/Shell (PSI)	(849)	51.17147	51.23556*	51.44587*
ΔP_e/Shell (PSI)	(850)	50.66039	50.71483*	50.77262*
ΔP_s (Total No. of Shells) (PSI)	(851)	51.23751	51.30705*	51.52313*
Q/Shell (Btu/Hr.)	(852)	57.16545	57.16545	57.16545
Fin Efficiency (ef)	(853)	50.97000	50.97000	50.97000
Tube Side Fouling Factor (ri)	(854)	48.15000	48.15000	48.15000
Shell Side Fouling Factor (ro)	(855)	48.15000	48.15000	48.15000
Tube Wall Resistance (rm)	(856)	47.38148	47.38148	47.38148
Tube Side Film COEF (Btu/Hr. °F FT^2)	(857)	54.10900	54.12887	54.12887
Shell Side Film COEF (Btu/Hr. °F FT^2)	(858)	52.75814	52.81724*	52.89932*
Uo Calc'd. (Fouled) (Btu/Hr. °F FT^2)	(859)	52.39873	52.42480	52.44596
Uo Used (Fouled) (Btu/Hr. °F FT^2)	(860)	52.32470	52.40030	52.40030
LMTD (°F) (Uncorrected)	(861)	52.36707	52.36707	52.36707
LMTD F	(862)	50.86757	50.86757	50.86757
Area Safety Factor $\left(\frac{U_o \text{ Calc-1}}{U_o \text{ Used}}\right)$ (100)	(863)	52.22797	51.61216*	52.11407*

* See Text.

FIGURE 4—Permitting the shell side pressure drop to increase does not decrease the shell size significantly.

TABLE 1—Basic Data for the Convection Heat Transfer Example

ITEM	Shell Side	Tube Side
Fluid	.....	Water
Fluid Flow, lbs/hr	34.6×10^3	0.1103×10^6
Temperature In, °F	163	85
Temperature Out, °F	104	100
Density, lbs/ft^3	0.41	62.4
Specific Heat, Btu/(lb) (°F)	0.8105	1.0
Term. Cond., Btu/(hr) (ft^2) (°F/ft)	0.021	0.3625
Viscosity, lb/(ft) (hr)	0.037	1.66
Max. Allow. △ P, psi	4.0	10.0
Fouling Factor	0.0015	0.0015

TABLE 2—Comparison of Calculated and Actual Tube Counts

Unit Size Length, Ft.	ΔP_s Max., psi	Number of Tubes Calc'd.	Actual	Precent Discrepancy
8	4	341	332	+2.67
12	4	233	228	+2.1
16	4	233	228	+2.1
8	3	421	412	+2.1
8	5	341	332	+2.67
8	7.5	341	332	+2.67

Note: It is a coincidence that all of the above discrepancies are plus.

TABLE 3—Basic Data for the Total Condenser Problem

ITEM	Shell Side	Tube Side
Fluid	n-C_4	H_2O
Fluid Flow, lbs/hr	22.050	0.203×10^6
Temperature In, °F	160	90
Temperature Out, °F	160	104.5
Liquid Density, lbs/ft^3	32.4	62.4
Vapor Density, lbs/ft^3	1.09	.....
Specific Heat, Btu/(lb) (°F)	.....	1.0
Therm. Cond., (Liq), Btu/(hr) (ft^2) (°F/ft)	0.0693	0.3625
Viscosity (Liq), lbs/(ft) (hr)	0.262	1.66
System Pressure, psig	110	40
Max. Allow. △ P, psi	10.0	10.0
Fouling Factor	0.0015	0.0015

TABLE 4—Comparison of Calculated and Actual Tube Counts

Unit Length, Ft.	Number of Tubes Calculated	Actual	Percent Discrepancy
8	335	332	+0.9
12	229	228	+0.4

Multiply both sides by G_{gm} and divide both sides by Prandtl number, $\frac{C_p\mu}{K}$

$$\frac{h'_o\ D_e}{K}\frac{(G_{gm})}{\left(\frac{C_p\mu}{K}\right)} = C\left(\frac{D_e\ G_{gm}}{\mu}\right)^{0.6}\left(\frac{C_p\mu}{K}\right)^{0.333}\left(\frac{\mu}{\mu_W}\right)^{0.14}\frac{(G_{gm})}{\left(\frac{C_p\mu}{K}\right)}$$

Cancel and rearrange:

$$\frac{h'_o}{C_p}\left(\frac{D_e\ G_{gm}}{\mu}\right) = C\left(\frac{D_e\ G_{gm}}{\mu}\right)^{0.6}\frac{\left(\frac{\mu}{\mu_W}\right)^{0.14}G_{gm}}{\left(\frac{C_p\mu}{K}\right)^{0.667}}$$

Transpose:

$$h'_o = C\frac{\left(\frac{D_e\ G_{gm}}{\mu}\right)^{0.6}\left(\frac{\mu}{\mu_W}\right)^{0.14}(G_{gm})(C_p)}{\left(\frac{D_e\ G_{gm}}{\mu}\right)\left(\frac{C_p\mu}{K}\right)^{0.667}}$$

$$h'_o = C\frac{(G_{gm})(C_p)\left(\frac{\mu}{\mu_W}\right)^{0.14}}{\left(\frac{D_e\ G_{gm}}{\mu}\right)^{0.4}\left(\frac{C_p\mu}{K}\right)^{0.667}}$$

The K reamins in the correlation as a part of the Prandtl number; however, the effect of any inaccuracy in the K will be reduced by the fractional exponent. Where the K is unknown or of doubtful accuracy, the Prandtl number for gases can be taken to be 0.8 in many cases.

The following correlation is programmed for plain tubes:

$$h'_o = C\frac{(G_{gm})(C_p)\left(\frac{\mu}{\mu_W}\right)^{0.14}}{\left(\frac{D_e\ G_{gm}}{\mu}\right)^{0.4}\left(\frac{C_p\mu}{K}\right)^{0.667}}$$

Constant C = 0.22 for plain tubes

In the past, C for low-finned tubes was taken as 70% of C for plain tubes.

$$\begin{aligned} C\ \text{(low-finned tubes)} &= (0.7)\ (C\ \text{for plain tubes} \\ &= (0.7)\ (0.22) \\ &= 0.155 \end{aligned}$$

Recent information indicates C for low-finned tubes is the same as C for plain tubes in actual operation. For the computer program, C for finned tubes was taken at 90% of plain tube C.

$$\begin{aligned} C\ \text{(low-finned tubes)} &= (0.9)\ (0.22) \\ &= 0.198 \end{aligned}$$

The following correlations is programmed for finned tubes:

$$h'_o = \frac{0.198\ \ Cp\ G_{gm}\ (\mu/\mu_w)^{0.14}}{(Re_{gm})^{0.4}\ (C_p\,\mu/K)^{0.667}}$$

The correlation for plain and finned tubes are computed by the Figure 1 logic diagram as follows:

Re_{gm} is computed:

$$Ac = \frac{BP\left[I.D._s - \left(\frac{I.D._s - 7/8}{P} + 1\right)(de)\right]}{144} \quad (12)$$

$$Ab = \frac{(K_1)\ (IDs)^2 - \left[\frac{(A)\ (N_t)}{0.785}\right]a_x}{144}$$

$$Agm = \sqrt{(Ac)\ (Ab)}$$

$$Ggm = \frac{W_s}{Agm}$$

$$Re_{gm} = \frac{de\ (G_{gm})}{12\ (\mu_s)}$$

Re_{gm} and G_{gm} are used in the above correlation for both finned tubes and plain tubes.

Total Condensation (Shell Side, Horizontal Plain Tubes). The correlation programed is based on the following Nusselt correlation:

$$h_o = \frac{1.47}{\left(\frac{\mu f^2}{Kf^3\ \rho f^2 g}\right)^{1/3}\left(\frac{4\,\Gamma}{\mu f}\right)^{1/3}}$$

$$\Gamma = (\text{Tube loading, } \frac{\text{lbs}}{\text{hr. ft}^2}) = w_1 = \frac{W_s}{L\ N_t}$$

From Kern, First Edition, p 266, "The splashing of condensate as it drips over successive rows of tubes causes h_o to be more inversely proportional to $N_t^{2/3}$ rather than N_t . . ." Design experience indicates this statement is substantially correct.

Therefore, Equation (1) will be modified and transposed for programing as follows:

$$w_1 = \frac{W_s}{L\ N_t^{\ 2/3}}$$

$$h_o = \frac{1.47}{(4)^{1/3}}\frac{\left(\frac{Kf^3\ \rho f^2\ g}{\mu f^2}\right)^{1/3}}{\left(\frac{W_s}{L\ N_t^{\ 2/3}\ \mu f}\right)^{1/3}} \quad (2)$$

Cancel the viscosity from the denominator by the numerator and consolidate constants,

$$h_o = 0.95\frac{\left(\frac{Kf^3\ \rho f^2\ g}{\mu f}\right)^{1/3}}{\left(\frac{W_s}{L\ N_t^{\ 2/3}}\right)^{1/3}}$$

TABLE 5—Tube Count[1] for 720 Combinations of Tube Sizes and Spacings

I.D. OF SHELL, IN CHES																Tube O.D., In	Spacing In	Pitch		
37	35	33	31	29	27	25	23¼	21¼	19¼	17¼	15¼	13¼	12	10	8					
1269	1143	1019	881	763	663	553	481	391	307	247	193	135	105	69	33	¾	15/16	Tri.	Fixed Tubes	ONE-PASS
1127	1007	889	765	667	577	493	423	343	277	217	157	117	91	57	33	¾	1	Tri.		
965	865	765	665	587	495	419	355	287	235	183	139	101	85	53	33	¾	1	Sq.		
699	633	551	481	427	361	307	247	205	163	133	103	73	57	33	15	1	1¼	Tri.		
595	545	477	413	359	303	255	215	179	139	111	83	65	45	33	17	1	1¼	Sq.		
1242	1088	964	846	734	626	528	452	370	300	228	166	124	94	58	32	¾	15/16	Tri.	Fixed Tubes	TWO-PASS
1088	972	858	746	646	556	468	398	326	264	208	154	110	90	56	28	¾	1	Tri.		
946	840	746	644	560	486	408	346	280	222	172	126	94	78	48	26	¾	1	Sq.		
688	608	530	462	410	346	292	244	204	162	126	92	62	52	32	16	1	1¼	Tri.		
584	522	460	402	348	298	248	218	172	136	106	76	56	40	26	12	1	1¼	Sq.		
1126	1008	882	768	648	558	460	398	304	234	180	134	94	64	34	8	¾	15/16	Tri.	U Tubes[2]	
1000	882	772	674	566	484	406	336	270	212	158	108	72	60	26	8	¾	1	Tri.		
884	778	688	586	506	436	362	304	242	188	142	100	72	52	30	12	¾	1	Sq.		
610	532	466	396	340	284	234	192	154	120	84	58	42	26	8	XX	1	1¼	Tri.		
526	464	406	356	304	256	214	180	134	100	76	58	38	22	12	XX	1	1¼	Sq.		
1172	1024	904	788	680	576	484	412	332	266	196	154	108	84	48	XX	¾	15/16	Tri.	Fixed Tubes	FOUR-PASS
1024	912	802	692	596	508	424	360	292	232	180	134	96	72	44	XX	¾	1	Tri.		
880	778	688	590	510	440	366	308	242	192	142	126	88	72	48	XX	¾	1	Sq.		
638	560	486	422	368	308	258	212	176	138	104	78	60	44	24	XX	1	1¼	Tri.		
534	476	414	360	310	260	214	188	142	110	84	74	48	40	24	XX	1	1¼	Sq.		
1092	976	852	740	622	534	438	378	286	218	166	122	84	56	28	XX	¾	15/16	Tri.	U Tubes[2]	
968	852	744	648	542	462	386	318	254	198	146	98	64	52	20	XX	¾	1	Tri.		
852	748	660	560	482	414	342	286	226	174	130	90	64	44	24	XX	¾	1	Sq.		
584	508	444	376	322	266	218	178	142	110	74	50	36	20	XX	XX	1	1¼	Tri.		
500	440	384	336	286	238	198	166	122	90	66	50	32	16	XX	XX	1	1¼	Sq.		
1106	964	844	732	632	532	440	372	294	230	174	116	80	XX	XX	XX	¾	15/16	Tri.	Fixed Tubes	SIX-PASS
964	852	744	640	548	464	388	322	258	202	156	104	66	XX	XX	XX	¾	1	Tri.		
818	724	634	536	460	394	324	266	212	158	116	78	54	XX	XX	XX	¾	1	Sq.		
586	514	442	382	338	274	226	182	150	112	82	56	34	XX	XX	XX	1	1¼	Tri.		
484	430	368	318	268	226	184	154	116	88	66	44	XX	XX	XX	XX	1	1¼	Sq.		
1058	944	826	716	596	510	416	358	272	206	156	110	74	XX	XX	XX	¾	15/16	Tri.	U Tubes[2]	
940	826	720	626	518	440	366	300	238	184	134	88	56	XX	XX	XX	¾	1	Tri.		
820	718	632	534	458	392	322	268	210	160	118	80	56	XX	XX	XX	¾	1	Sq.		
562	488	426	356	304	252	206	168	130	100	68	42	30	XX	XX	XX	1	1¼	Tri.		
478	420	362	316	268	224	182	152	110	80	60	42	XX	XX	XX	XX	1	1¼	Sq.		
1040	902	790	682	576	484	398	332	258	198	140	94	XX	XX	XX	XX	¾	15/16	Tri.	Fixed Tubes	EIGHT-PASS
902	798	694	588	496	422	344	286	224	170	124	82	XX	XX	XX	XX	¾	1	Tri.		
760	662	576	490	414	352	286	228	174	132	94	XX	XX	XX	XX	XX	¾	1	Sq.		
542	466	400	342	298	240	190	154	120	90	66	XX	XX	XX	XX	XX	1	1¼	Tri.		
438	388	334	280	230	192	150	128	94	74	XX	XX	XX	XX	XX	XX	1	1¼	Sq.		
1032	916	796	688	578	490	398	342	254	190	142	102	68	XX	XX	XX	¾	15/16	Tri.	U Tubes[2]	
908	796	692	600	498	422	350	286	226	170	122	82	52	XX	XX	XX	¾	1	Tri.		
792	692	608	512	438	374	306	254	194	146	106	70	48	XX	XX	XX	¾	1	Sq.		
540	464	404	340	290	238	190	154	118	90	58	38	24	XX	XX	XX	1	1¼	Tri.		
456	396	344	300	254	206	170	142	98	70	50	34	XX	XX	XX	XX	1	1¼	Sq.		

[1] Allowance made for Tie Rods.
[2] R.O.B. = 2½ x Tube Diameter. Actual Number of "U" Tube is one-half the above figures.
D.L.W. — 3/5/58.

$$\left(\frac{1}{N_t \, ^{2}/_{3}}\right)^{1/3} = \left(\frac{1}{N_t}\right)^{1/3} N_t^{\,1/9} \qquad (3)$$

Therefore,

$$h_o = 0.95\left(\frac{Kf^3 \, \rho f^2 \, g}{\mu f}\right)^{1/3}\left(\frac{L \, N_t}{W_s}\right)^{1/3}\left(\frac{1}{N_t}\right)^{1/9} \qquad (4)$$

Equation (4) is programed.

Tube Side Film Coefficient, hi. If the tube side fluid is water, hi is computed directly.

$$hi_{H_2O} = 150 \; (1 + 0.011)\frac{\mu_t}{i.\,d._t^{\,0.2}}$$

For tube side fluids other than water, Ret is computed:

$$Ret = \frac{(i.\,d.)_t \; (\mu t) \; (\rho_t) \; 3600}{12 \; (\mu t)}$$

Then hi is computed:

$$hi = \frac{0.027\ K_t}{(i.\ d.)\ t/12} (Ret)^{0.8} \left(\frac{Cp\mu}{K}\right)^{0.333} \left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Number of Tubes Per Shell, N_t — The number of tubes per shell is affected by:

- Shell diameter
- Tube size
- Tube pitch
- Type of unit; i.e., fixed tube sheet, floating head, or U-tube
- Minimum clearance between the tube bundle periphery and the shell inside diameter
- Type of channel baffle; i.e., ribbon, pie shape, vertical, etc.
- Number of tie-rods between tube sheets
- U-tube bundle radius of bend of inside tube row

It was decided to set the following variables at the following values:

- Minimum clearance between the tube bundle periphery and shell inside diameter at 3/8 inch (based on fabricator's experience)
- Type of channel baffle:

a. Fixed Tube Sheet

No. of Passes	Type of Channel Baffle
1	None
2	Center ribbon
4	15¼-inch shell I.D. and less—pie shape 17¼-inch shell I.D. and greater—ribbon
6	Ribbon baffles for all shell sizes
8	Ribbon baffles for all shell sizes

b. U-Tubes

No. of Passes	Type of Channel Baffle
2	Pie Shape
4	Pie Shape
6	Vertical baffle
8	Vertical baffle

- U-tube bundle inside tube row radius of bend = (2½) (Tube O.D.)
- Type of unit = fixed tube sheet or U-tube
- Number of tie-rods:

Shell I.D.	No. of Tubes Removed to Allow for Tie-Rods
8 to 13¼	4
15¼ to 29	6
31 to 37	8

The shell diameter, tube size, tube pitch, and tube passes were allowed to vary as described above. This lead to 720 combinations with a different tube count for each. Since the available program space is only 863 words, it was obviously impossible to store the 720 different tube counts in registers. Therefore, it became necessary to develop a tube count correlation that could be programed in a few commands. Large scale tube sheet layouts were made by a draftsman. A careful tube count was made for all 720 combinations. This procedure was necessary because of the disagreement between reference sources regarding the tube counts for the same arrangement of tube size, tube passes, etc. The 720 tube counts obtained (see Table 5) from these layouts were then correlated.

The tube count is based on the shell cross-section area available for tubes. The variables are related as follows:

- Let A_o = Shell cross section area decreased to allow for a specified clearance between shell I.D. and tube bundle.

$$A_o = [I.\ D._S - K_1]^2\ \frac{\pi}{4}$$

Due to the nonlinear relationship between N_t and $I.D._s$, it became necessary to add constant K_2. Thus,

$$A_o = [I.\ D._S - K_1]^2 \frac{\pi}{4} + K_2$$

- Let A = Actual shell cross section area available for tubes.
  = A_o minus shell cross section area equivalent to channel baffles.

For 1 tube pass exchangers:

$$A = A_o$$

- Area equivalent to channel baffles = PRK_o. This is based on the assumption that one channel baffle deletes one row of tubes. Therefore, this area has a width equal to the tube pitch, P, and a length equal to actual length, RK_o of the channel baffles.

Therefore,

$A = A_o - PKR_o$
R = Channel baffle length at shell centerline = $[I.\ D._S - K_1]$
K_o = Variable to compensate for the number of tube passes.

For the combination of shell I.D. and number of tube passes per shell which are practical to fabricate, the derivative $\frac{d\ (L_1)}{d\ (N_2)}$ is very nearly constant.

L_1 = Average channel baffle length
N_2 = Number of tube passes per shell

Therefore, the variable K_o has the form

$K_o = (a)\ (x) + b$
x = Number of tube passes

For the program:

$K_o = K_3\ N_2 + K_4$

Over-all Correlation, N_t

a. Square Pitch, N_t

$$= A/P^2$$

b. Triangular Pitch, N_t

$$= A(1.225)\ (P)^2$$

Over-all Correlation Programed, N_t

a. Square Pitch, N_t

$$= \frac{\left[(I.\ D._S - K_1)^2 \frac{\pi}{4} + K_2\right] - (P)\ (I.D._S - K_1)\ [(K_3)\ (N_2) + (K_4)]}{(P)^2}$$

b. Triangular Pitch, N_t

$$= \frac{\left[(I.\ D._S - K_1)^2 \frac{\pi}{4} + K_2\right] - (P)\ (I.D._S - K_1)\ [(K_3)\ (N_2) + (K_4)]}{1.225\ (P)^2}$$

• Value of K_1, K_2, K_3, and K_4 for Fixed Tube Sheets

Tube O.D., in.	Pitch Spacing, in.	K_1	K_2	K_3	K_4
¾	15/16△	1.0800	—0.9000	0.6900	—0.8000
¾	1△	1.0800	—0.9000	0.6900	—0.8000
¾	1□	—1.0400	—0.1000	0.4300	—0.2500
1	1¼△	1.0800	—0.9000	0.6900	—0.8000
1	1¼□	—1.0400	—0.1000	0.4300	—0.2500

The computed tube counts agree with the actual tube count within +3% and —4% and usually within ½%. There are some exceptions to this in the small shells; i.e., 8″ and 10″. The small shells have only 15 to 35 tubes; therefore, a difference of 2 tubes would be a 6% to 12% disagreement.

OTHER EQUATIONS USED IN THE PROGRAM

Heat Transfer Coefficient, U_o. The first step is to calculate the U_o required (fouled).

$$U_{os} = \frac{Q}{(N_t)\ (A_{ot})\ L_t)\ (LMTD)\ (F_{LMTD})}$$

Next compute U_o required (clean)

$$\frac{1}{U_o\ req'd\ (clean)} = \frac{1}{U_{os}} - r_i\left(\frac{A_o}{A_i}\right) - r_m\left(\frac{A_o}{A_m}\right) - r_o.$$

After h_o and h_i have been computed for the specific physical data (input) and the particular geometric arrangement (the arrangement the computer has evolved thus far in proceeding through the logic pattern), the U_o available (clean) is computed.

$$\frac{1}{U_o\ avail.\ (clean)} = \frac{1}{h_o} + \frac{A_o}{A_i\ h_i}.$$

U_o calculated (fouled) is then computed.

$$\frac{1}{U_o\ calc'd\ (fouled)} = \frac{1}{U_o\ avail.\ (clean)} + \Sigma\ Heat\ Transfer\ Resistance.$$

Then the area safety factor is computed.

$$Area\ (S.\ F.) = \left(\frac{U_o\ calc'd}{U_o\ used} - 1\right)(100)$$

The computer asks the question: Is the area safety factor less than the minimum area safety factor? For an affirmative answer some change is made in the geometric arrangement. If the answer is negative, the computer proceeds to the next design parameter.

Tube Side Pressure Drop, $\triangle P_t$. First, compute Re_t.

$$Re_t = \frac{(I.\ D._t)\ (u_t)\ (\rho_t)\ (3600)}{(12)\ (\mu_t)}$$

After Re_t has been compared to Re_t Min. as shown in Figure 1, f_t is computed.

$$f_t = 0.0014 + \frac{0.125}{(Re_t)^{0.32}}$$

Then $\triangle P_t$ is computed.

$$\triangle P_t = 0.323\ (N_2)\ (S)\ (u_t)^2\left[\frac{(f_t)\ (L_t)}{I.\ D._t} + 0.084\right]$$

Shell Side Pressure Drop, $\triangle P_s$. Shell side pressure drop is computed as the sum of the baffle window pressure drop and the shell bundle pressure drop between the shell baffles.

$$\triangle P_s = \triangle P_b + P_c$$

First G_b and G_c are computed as shown in the section on "Convection Heat Transfer (Shell Side)". Next friction factor, f_s, is computed.

For Triangular Tube Pitch:

$$f_s = \frac{0.23 + \frac{0.11}{[(P/D) - 1]^{1.08}}}{Re_c^{0.15}}$$

For Square Tube Pitch

$$f_s = \frac{0.044 + \frac{0.08\ (P/D)}{[(P/D) - 1]^n}}{Re_c^{0.15}}$$

where $n = 0.43 + \frac{1.13}{(P/D)}$

Separate correlations are used for finned and plain tubes.

For Finned Tubes:

$$\triangle P_b = \left[\frac{2.9\ (G_b)^2}{(10)^{13}\ Sp.\ Gr.}\right](1.2)\ (n_b)$$

$$\triangle P_c = \left[\frac{1.2\ (f_s)\ (G_c)^2}{(10)^9\ (\rho_s)\ (g_c)\ (\mu/\mu_w)^{0.14}}\right](n_t)\ (n_b + 1$$

For Plain Tubes

$$\triangle P_b = \left[\frac{2.9\ (G_b)^2}{(10)^{13}\ Sp.\ Gr.}\right](n_b)$$

$$\triangle P_c = \left[\frac{1.07\ (f_s)\ (G_c)^2}{(10)^9\ (\rho_s)\ (g_c)\ (\mu/\mu_w)^{0.14}}\right](n_t)\ (n_b + 1)$$

Rate Exchangers This Computer Way . . .

SYMBOLS USED

A_b = Net free area of flow through baffle windows, sq. ft.

A_c = Net free area of cross flow betwen baffle on shell side of tube bundle, sq. ft.

A_i = Tube inside area, sq. ft./lin. ft.

A_O = Tube outside area, sq. ft./lin. ft.

C_{ps} = Specific heat, shell side, Btu/(lb.) (°F)

C_{pt} = Specific heat, shell side, Btu/(lb.) (°F)

$D_e = \frac{d_e}{12}$

d_e = An equivalent diameter for finned tube equal to the diameter of a hypothetical plain tube with the same inside diameter and the same volumetric displacement (or with the same plane projection as the finned tube), inches.

D_i = Tube I. D., ft.

D_r = Finned tube root diameter, ft.

D_r (Plain Tubes) = D_o (Tube O.D., ft.)

ef = Fin efficiency factor

f_s = Shell side friction factor

f_t = Tube side friction factor

g_c = Gravitational constant, ft./(hr.) (hr.) (4.18×10^8)

g'_c = Gravitational constant, 32.2 ft./(sec.) (sec.)

$G_b = \frac{W_S}{A_b}$

$G_c = \frac{W_S}{A_c}$

$G_{gm} = \frac{W_S}{\sqrt{(A_c)(A_b)}}$ Mean shell side mass rate

h_i = Inside tube film heat transfer coefficient, Btu/(hr.) (ft.) (°F)

h_O = Outside tube film heat transfer coefficient, Btu/(hr.) (ft.) (°F)

I. $D._S$ = Shell I. D., inches

I. $D._t$ = Tube I. D., inches

K_1, K_2, K_3 and K^4 = Tube count correlation constants

K_f = Film thermal conductivity, Btu/(hr.) (sq. ft.) (°F/ft.)

K_s = Btu/(hr.) (ft^2) (°F/ft.)

K_t = Btu/(hr.) (ft^2) (°F/ft.)

K_m = Tube metal thermal conductivity, Btu/(hr.) (ft^2) (°F/ft.)

K_{ws} = Btu/(hr) ($ft.^2$) (°F/ft.)

K_{ws} (Liquid) = Btu/ft.-hr. @ Wall

L = Tube length (single tube), ft.

L_f = Final tube length, ft.

L_i = Initial tube length, ft.

L_{fw} = Fin thickness, ft.

L_w = Wall thickness, ft.

$\triangle L$ = Incremental tube length, ft.

N_2 = Number of tube passes

N_t = Total number of tubes

n_b = Number of baffles

n_i = Number of tube rows between centers of gravity of adjacent baffle windows

P = Tube pitch, inches

$\triangle P_b$ = Baffle window pressure drop, psi

$\triangle P_c$ = Shell bundle pressure drop, psi

$\triangle P_s$ = Over-all shell side pressure drop, psi

$\triangle P_t$ = Tube side pressure drop, psi

Q = Btu/hr.

$Re_{gm} = \frac{D\ G_{gm}}{\mu}$ Mean shell side Reynolds number

Re_t = Tube side Reynolds number $\frac{D\ G}{\mu}$

r_i = Tube side resistance

r_m = Tube wall metal resistance, $\frac{(hr.)\ (ft.)\ (°F)}{Btu}$

r_O = Shell side resistance

S = Specific gravity of fluid [H_2O (Liq.) = 1.0]

S. F. = Safety Factor

Sp. Gr. = [H_2O (Liq.) = 1.0]

T_1 = Hot fluid inlet, °F

T_2 = Hot fluid exit, °F

t_1 = Cold fluid inlet, °F

t_2 = Cold fluid exit, °F

^{t}Avg. H_2O = Average tube side water temperature, °F

u_t = Tube side velocity, ft/second

U_O Max. = Maximum allowable U_o, Btu/(hr.) (°F) (ft^2)

U_{os} = U_o used (fouled), Btu/(hr.) (°F) (ft^2)

u_t Min. = Minimum tube side velocity, ft/second

W'_s = Average shell side vapor, lbs. hr.

W_s = Total shell side fluid, lbs./hr.

W_t = Total tube side fluid, lbs./hr.

Greek Symbols:

μf = Film viscosity, lbs./(ft.) (hr.)

μs = Shell side viscosity, lbs./ft.-hr.

μt = Tube side viscosity, lbs./ft.-hr.

μws = Shell side viscosity @ wall, lbs./ft.-hr.

μws (Liquid) = Shell side (Liq.) viscosity @ wall, lbs./ft.-hr.

μwt = Tube side viscosity @ wall, lbs./ft.-hr.

ρf = Film density, lbs./cu.ft.

ρs = Shell side density, lbs./cu.ft.

ρs (Vapor) = Shell side (Vapor) density, lbs./cu.ft.

ρs (Liquid) = Shell side (Liq.) density, lbs./cu.ft.

ρt = Tube side density, lbs./cu.ft.

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Applied Hydrocarbon Thermodynamics

Part 25: Summary of the previous 24 parts

Here is a recapitulation of the series thus far. The first 25 parts will be published in book form with enlarged figures. See the announcement at the end of this article

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IN THE PREVIOUS 24 installments of this series material has been presented on: (1) Equations of state and other correlations of PVT data, (2) Mollier charts for pure hydrocarbons, (3) Compression and expansion of gases, (4) Flow calculations for compressible fluids, (5) Flash vaporization correlations for petroleum, (6) Integral technique for petroleum distillation calculations, (7) Fundamentals of vapor-liquid phase equilibria, (8) Generalized pressure-temperature-composition correlations for vapor-liquid K values, (9) Nomograph and convergence pressure correlations of vapor-liquid K values, and (10) Fugacity and activity coefficients for components of liquid and vapor mixtures.

The emphasis has been on data compilations and calculation methods as the development and use of these are the essence of applied thermodynamics. As required, the equations involved are developed from basic concepts. Completely rigorous theoretical developments are not given in all cases. Many empirical correlations are included. In some cases the development and application of these empirical correlations involves the use of very little thermodynamics theory. Although not essential, an understanding of the background of such charts is desirable.

In Part 1 the fundamentals of the thermodynamics were reviewed. This included the first and second laws and the derivations of important equations. These relationships apply to constant composition systems (i.e., pure substances and mixtures of unchanging composition). Basic equations leading to the development of fugacity relationships for components of mixtures were presented in Parts 18 and 22. Later in the series other fundamental equations will be given.

Following is a brief resume of the material presented on the ten topics listed above.

PVT Relationships. Four types of pressure-volume-temperature correlations are given; namely, (1) equations of state of the van der Waals type, (2) virial type equation of state, (3) generalized compressibility factor correlations and (4) specific volume or density diagrams. These PVT relationships have two main purposes, i.e., providing a PVT data correlation (graphical or analytical) basis for: (a) deriving thermodynamic properties, and (b) finding volumes or densities.

The van der Waals type equation of state gives pressure as a function of temperature and volume and has two important features, i.e., corrections for internal pressure and the volume occupied by the molecules. Since originally proposed in 1893, this type of equation of state has been improved by adding more terms and modifying the form. The Benedict-Webb-Rubin equation of state is the most recent equation of this type.

The virial equation of state is a power series where the PV product is a function of density or pressure. There are two virial equations, known as the Leiden and Berlin form virial equations, respectively. In the Leiden form, PV is a power series of density and in the Berlin form PV is a power series of pressure. The coefficients of these equations are functions of temperature. The Leiden form is more fundamental and gives a better representation of data for the same number of coefficients but the Berlin form is more convenient.

An improved generalized compressibility factor correlation, giving the PV/RT factor as a function of reduced pressure, reduced temperature and acentric factor, is presented. This correlation is in two parts, one for a simple fluid and the other to correct for departure from a simple fluid. The acentric factor is the index of departure from a simple fluid. This new correlation does well for pure substances. No general method for applying this correlation to mixtures has been devised as yet.

It is more convenient, and of sufficient accuracy for some problems, to use the generalized correlation that gives PV/RT as a function of reduced pressure and temperature only. The correlation is applied to mixtures by the pseudo critical concept.

Specific volume vs. temperature and pressure charts are presented for eight light hydrocarbons. Also liquid density correlations for petroleum fractions are given. These give density as a function of the 60° F density, temperature, pressure and viscosity (or average boiling point).

Applied Hydrocarbon Thermodynamics...

Partial volumes for components of liquid and vapor phases are not generally available. Compilations of partial volumes are needed, however, because pure component volumes are not additive to give the volumes of mixtures. Such partial volume data would be especially valuable for gases in liquid solutions and heavy components that are in vapor solution. Better volume data for the coexisting saturated vapor and liquid phases of mixtures would be of help in correlating vapor-liquid phase equilibria ratios.

Mollier Charts. Pressure vs. enthalpy type of Mollier charts are given for eight light hydrocarbons. The subcooled liquid, superheated vapor and the coexisting liquid-vapor regions are covered in these charts. Besides the saturated liquid and vapor boundry curves, lines of constant temperature, volume and entropy are included on these charts.

The reference state is the ideal gas at 0°R so the enthalpy is zero for the gas at 0°R and 0 psia. This is one of several reference states that are used for enthalpies. Ideal gas at 0°R was chosen here to agree with the API Research Project 44 selected values of properties for hydrocarbons.

Similar Mollier charts are available elsewhere for other substances, including the lighter gases and many refrigerants.

Methods of preparing and testing Mollier charts for internal consistency are discussed also. New charts for other substances can be prepared as required.

There is no method available at the present for combining readings from Mollier charts for two or more substances. Such an application for mixtures involves the effects of composition, including vapor-liquid phase equilibria. It is unlikely that a general method for combining pure component Mollier charts will ever be developed. It seems much too complicated.

Compression and Expansion of Gases. Data and methods were presented for calculating temperature changes and theoretical work for the compression and expansion of gases. These technical tools are based on the use of simple relationships that define the changes of volume and temperature with pressure.

It was shown that isentropic and polytropic changes of volume and temperature with pressure for earl gases can be represented by simple exponential expressions. Generalized and specific charts for these exponents were developed for hydrocarbons and natural gas. These exponents are similar to the heat capacity ratio but differ from C_p/C_v for real gases. Also the exponents for volume and temperature changes are not the same either.

Various compression efficiencies are refined and discussed. These are: "adiabatic" efficiency, "volumetric" efficiency, "reversible" efficiency, and "mechanical" efficiency. The "reversible" efficiency involves entropy production, which is included in the discussion.

Flow of Compressible Fluids. The flow of gases and of gas-liquid mixtures, for which the density and temperature change appreciable with pressure, was covered in Part 11. Nozzle flow and pipe flow were covered. Compressibility factors and the exponents defining the changes of volume and temperature with pressure were the fluid properties used in this development.

Energy balances that included the kinetic energy, pressure energy and internal energy and friction were the basis of the equations derived. For these purposes the "heat added" and "shaft work done" terms were taken as zero. Friction was also taken as zero in the nozzle flow application. Friction was included in the application of these energy balances to the general solution for the flow of gas and gas-liquid in transfer lines.

Nozzle flow is taken as isentropic (reversible and adiabatic) while transfer line flow is considered isenthalpic (irreversible and adiabatic). Illustrating examples are included for the transfer line flow.

Flash Vaporization of Petroleum Fractions. Empirical correlations are presented in Parts 12 and 13 relating the equilibrium flash vaporization (percent vaporized vs. temperature) curve for petroleum fractions with the two analytical assay distillations, i.e., the ASTM (American Society for Testing Materials) and the TBP (true boiling point). The basic ASTM-TBP-EFV correlations are for atmospheric and 10 mm pressure.

Also included are methods for translating the TBP and EFV curves to other pressures. Conversion from atmospheric pressure involves using the critical and focal points. Conversion to subatmospheric pressures uses a separate correlation. Also included are charts for estimating the ASTM assays and gravities of the equilibrium vapor and liquid from flash vaporization.

These correlations are based on experimental data taken on many petroleum stocks. The correlations are satisfactory for light and middle oils but are not very reliable for the reduced crudes and the complete range oils. It appears that such empirical correlations can not represent the volatility characteristics of these heavier oils adequately.

Another disadvantage of this empirical flash vaporization method is that it is limited to single stage equilibrium separations. It is not convenient to apply it to multistage separations. Because of these limitations it is of interest to consider another approach.

Integral Technique for Petroleum Distillation Calculations. A new technique for making petroleum distillation calculations is presented in Parts 14 through 17.

IN THE PREVIOUS 24 installments of this series material has been presented on: (1) Equations of state and other correlations of PVT data, (2) Mollier charts for pure hydrocarbons, (3) Compression and expansion of gases, (4) Flow calculations for compressible fluids, (5) Flash vaporization correlations for petroleum, (6) Integral technique for petroleum distillation calculations, (7) Fundamentals of vapor-liquid phase equilibria, (8) Generalized pressure-temperature-composition correlations for vapor-liquid K values, (9) Nomograph and convergence pressure correlations of vapor-liquid K values, and (10) Fugacity and activity coefficients for components of liquid and vapor mixtures.

This new method is called the "integral technique" because an integration rather than a summation of the component volatilities is employed in the application. By this new method a petroleum fraction is treated as a continuum mixture of an infinite number of components of infinitesimal size instead of a finite number of hypothetical components of finite size.

In this method vaporization calculations are made for each of several points on the mixture assay using the vapor liquid K values at the system conditions for the infinitesimal components represented by the points on the mixture assay. These vaporization calculations may be single stage, multistage or they may be bubble or dew point calculations. In all cases the calculations are made for given or assumed temperatures and total quantities of vapor and liquid. In other words, relative component distribution calculations are made for each point on the mixture assay for assumed or given parameters. These parameters are then checked by integrating these relative component distributions and integrating for the entire composition range to check the starting parameters. From the final and coverged integrations the assays of the equilibrium products are computed.

At the present state of development the integral method is based on the true boiling point assay. Points on the true boiling point curve are used in the component distribution calculations described above. Equilibrium vapor and liquid product compositions found from the converged integrations are expressed in the same type of assay as characterized the feed stock.

Other methods of assaying the feed and equilibrium products may be used in place of the TBP. Gas chromatography is a likely assay method for petroleum fractions. Changing from the TBP to gas chromatography would only change the method of characterising the feed and products. There would be no change in the component distribution and integration calculations for the separation.

In addition to the basic integral technique, that is described in Part 14, with illustrating examples, a simplified integral method is presented for making flash vaporization calculations from the terminal volatilities of the feed. In this short cut procedure, the component distribution and the integration calculations are all made analytically and the results put into chart form. A total of eleven charts have been prepared and presented. From these flash conditions and the TBP curve conversions can be found.

A method is described for deriving the vapor-liquid K values from experimental equilibrium flash vaporization data, which includes TBP assays on the equilibrium vapor and liquid. Tentative K and α values are given for the application of this integral method.

Fundamentals of Vapor-Liquid Equilibria. The thermodynamic fundamentals of vapor-liquid phase equilibria were discussed in Part 18. This included conditions for equilibrium, chemical potential, fugacity and the fugacity and activity coefficients. Generalized charts for the vapor pressures and the fugacity coefficients of pure substances were presented. Basic equations for obtaining the fugacity and activity coefficients for mixture components from PVTX data were given.

Thermodynamic requirements for coexisting equilibrium vapor and liquid phases were discussed near the end of Part 20. Relationships for isothermal and isobaric conditions are developed. These involve the mixture volume and enthalpy values, which make them rather impractical. To avoid these complications it is necessary to go to an equation for combined isobaric and isothermal conditions. Such an equation is developed and illustrated with the generalized fugacity coefficients from the correlation employing molar average boiling point as the composition parameter.

It was pointed out that it is not physically possible to keep temperature and pressure both constant while changing composition. Very little error results from applying the isothermal and isobaric equation to isothermal data, however.

Generalized PTC Vapor-Liquid K Values. Generalized and specific correlations giving the vapor-liquid K values in terms of the vapor and liquid fugacity coefficients have been developed and are presented in graphical form in Parts 19 and 20. The generalized correlations give the vapor and liquid fugacity coefficients as functions of reduced temperature, reduced pressure and boiling point ratio.

The boiling point ratio is a composition effect parameter, which is defined as the ratio of the molal average boiling point of vapor (or liquid) mixture to the boiling point of the component, both being absolute temperatures. The ratio of the liquid fugacity coefficient to the vapor fugacity coefficient is multiplied by the vapor pressure-system pressure ratio to give the actual K value.

K value correlations of this type were prepared for individual hydrocarbons. In these charts the parameters are temperature, pressure and molal average boiling point in actual engineering units. Vapor pressures for the applications of these charts must be the same used in developing the correlations. Since vapor pressure values above the critical temperature are required, a consistent and reproducible extrapolation was made and the results included in graphical and tabular form.

These empirical PTC value correlations were based on fugacity coefficients obtained from the Benedict-Webb-Rubin equation of state for twelve light hydrocarbons. The molal average boiling point had been used by these authors as a composition parameter in correlating their original fugacity coefficient values. This parameter should not be used for other than mixtures of the paraffinic and olefinic hydrocarbons. The generalized correlations would not give good results for mixtures containing aromatic hydrocarbons.

Nomographic and Convergence Pressure Correlations. Because of the complexity of the theoretical relationships for fugacities, many engineers use charts prepared from experimental K values. The nomograph is one type of chart that is widely used. The different types of K value nomographs are discussed in Part 21. Two nomographic correlations are illustrated. Both of these include the convergence pressure as a parameter.

The convergence pressure concept is an observed phenomenon; i.e., isotherms for the components of a mixture on K vs. P coordinates all intersect at K = 1.0 and a pressure that is called the convergence pressure. This is a useful point of reference for high pressure K values.

It is not an adequate composition parameter for representing non-ideality of mixtures, however. Several types of convergence pressure K charts have been published. In addition to two nomographic forms shown in Part 21, samples of the log K vs. log P type of nomographic charts are included.

In one correlation the K value at 10 psia is used as an intermediate correlating parameter. This is most convenient for graphical and computer representation of the K values. This K_{10} correlating technique is believed to be rather limited in its applicability, however.

Fugacity and Activity Coefficients of Liquid and Vapor Mixtures. A combination of theoretical and empirical methods seems to be the most practical way for developing the improved K value correlations that are required. It also appears that the best final correlation will consist of three terms; namely, (1) ideal K charts for individual components, (2) vapor activity coefficient relationships that define the departure of the vapor phase from ideality and (3) liquid activity coefficient relationships that define the departure of the liquid phase from ideality. Steps toward this objective are made in Parts 22, 23 and 24.

Activity coefficients have more physical significance than do the fugacity coefficients but they are more difficult to evaluate. An activity coefficient is the ratio of the fugacity coefficient of a component in a mixture to the fugacity coefficient of the component in the pure state, both coefficients being at the same temperature and pressure conditions. In other words, the pure component is the reference state. In some cases the reference state is a hypothetical liquid or vapor. This would be the case for a gas in liquid solution and for a heavy component in a gas mixture. It is necessary to use other means for finding these pure component reference state fugacity coefficients at these hypothetical conditions. Extrapolation or empirical methods are used to find these reference fugacity coefficients. As long as the same values are used in developing the activity coefficient correlations and in applying them, the exact values are not very important. It is important to have consistency and the best values for generalizations.

A hypothetical vapor phase fugacity coefficient correlation is presented. This gives the f/P ratio as a function of reduced temperature, pressure and acentric factor.

Virial equation of state relationships for fugacity coefficients are developed and discussed. These can be used for the vapor phase but their utility is limited by the lack of coefficients for the virial equations.

Charts for finding the fugacity coefficients of vapor components (pure state and in mixtures) by two generalized methods are presented. These were prepared from the equations of Joffe and Redlich-Kwong. These charts are based on simplified assumptions so the charts should be regarded as approximations and not rigorous solutions for the vapor fugacity coefficients.

For the liquid phase of hydrocarbon systems the activity coefficient can be correlated by the van Laar equation for which the coefficients are predicted from liquid volume and Hildebrand solubility parameter. In Part 24 this method is presented. Ways of evaluating the parameters are included and a graphical solution of the relationships are given. The reliability of the method is presented.

Using the van Laar equation in the corrected ideal K value method, described above, requires the evaluating of the pure liquid fugacity coefficients that are consistent with the van Laar equation so as to complete the three-way correlation.

Future Topics. More material on vapor-liquid values will be presented in a latter installment after some work that is now in progress is completed.

Mollier charts for other substances may be prepared.

Partial volumes and densities will require further attention.

Partial enthalpies of mixture components and the heats of vaporization are other topics for the future.

Reaction equilibria and heats of reaction are also of interest and will be covered.

TO BE CONTINUED

This Series of Articles in Book Form

Over the past several years, "Applied Hydrocarbon Thermodynamics" by Professor Wayne Edmister has created a considerable amount of interest, and every month we get many letters asking if it is possible to get extra copies of the entire series. Since we have long run out of earlier parts of this series, Gulf Publishing's Book Publishing Division has decided to print all of this material in hard-back book form. But this book will be more than just a compilation of the articles as it will contain many charts and graphs previously unpublished, and therefore unavailable. Also, many of the charts which were published will be enlarged so that you will find them much easier to work with. And on top of that, this entire book will be completely indexed for your convenience.

This book will be available for purchase from Gulf Publishing Company's Book Publishing Division about mid-1961, but you can reserve your copy now by circling E 32 on the green card in the back of the book and sending it in today. You'll get one of the first copies.

Petrochemical Outlook Bright for 1961

A new spurt of growth and entry into new areas will keep production climbing well into 1961

Raphael Katzen, Consulting Engineer
Cincinnati

A RAPID INCREASE in production of petrochemicals in the later half of 1959 has continued into 1960. After a brief slowdown during the middle of this year, the last few months indicate a continued rise in the production curve. This should continue well into 1961.

With this generally steady rate of increase in production and consumption over the three-year period (1959-1961), many areas currently showing over-capacity are heading toward a tight supply situation. Only a relatively few products show sufficient excess capacity for this condition to persist over the next several years. In some cases, a tight capacity situation already exists.

PRICE TRENDS

As indicated in Table 1, there has been continued stability in price levels for most major petrochemicals during the past year. This is not as healthy a situation as may first appear, when it is recognized that some of these prices have held at fixed levels for the past three to six years, during a period of steadily rising operating costs. The result is shrinkage in profit margins, and reduced return on investment.

Only one major product, ammonia, shows a price increase during the past year. This rise is essentially a readjustment from abnormally depressed levels in 1959 when over-capacity was excessive.

On the other hand, five major petrochemicals de-

TABLE 1—Price Trends for Major Petrochemicals[1]
(Cents per pound, except where noted)

	3rd Quarter 1959	3rd Quarter 1960
Stable		
► Acetaldehyde	10	10**
► Acetic Acid	10	10*
► Acetic Anhydride	14	14***
► Butanol (secondary)	12½	12½*
► Ethanol (per gallon)	52	52
► Ethylene Glycol	13½	13½**
► Ethylene Oxide	15½	15½****
► Iso-Propanol (per gallon)	42	42
► Methanol (per gallon)	30	30
► Phenol	16½	16½
► Toluene (per gallon)	25	25
► Vinyl Chloride	11	11*
Increases		
▲ Ammonia	4¼	4½
Decreases		
▼ Acrylonitrile	27	23
▼ Acetone	8½	8
▼ Butadiene	14½	13½
▼ Vinyl Acetate	17½	15½
▼ Xylene (per gallon)	29	28½

* Stable 3 years
** Stable 4 years
*** Stable 5 years
**** Stable 6 years

Table 2—Major Petrochemicals—Capacity and Production*

(Millions of Pounds)

Petrochemicals	Capacity Estimates		PRODUCTION					Percent Petrochemical 1959
			Actual		Estimated			
	1960	1961	1958[2]	1959[3]	1959[2]	1960	1961	
Hydrocarbon Intermediates								
Aliphatic								
Ethylene	5600	6000	4149	4954	4500	5300	5600	100
Propylene & Mixtures	2300	3200	2016	2516	2100	2800	3100	100
Butylene & Mixtures	2600	3000	2027	2144	2100	2300	2500	100
Butadiene	2450	2550	1443	1816	1600	2000	2100	100
Acetylene	1250	1300	650	815[5]	700	875	950	25
Aromatic								
Benzene	3700	4000	2000	2540	2200	2700	2900	60
Ethylbenzene	....	....	....	1422	....	1500	1550	60
Dodecylbenzene	....	....	....	494	....	530	560	60
Toluene	2700	3000	1720	2030	1800	2200	2400	89
Xylene	2000	2300	1500	1770	1600	1900	2100	96
Styrene	1600	2100	1224	1571	1250	1700	1800	75
Cyclohexane	....	....	....	388	....	420	450	100
Naphthalene	450	600	....	425	....	450	550	0
Hydrocarbon Polymers								
Polyethylene	1500	1800	865	1195	950	1350	1500	100
Polypropylene	100	300	....	20	20	50	100	100
Synthetic Rubber	2900	3400	2202	2825	2300	3000	3200	80
Phenol	800	900	506	692	550	750	800	74
Ammonia	10400	11000	7500	8800[5]	8000	9600	10200	96
Urea	1700	1800	1061	1261	1200	1350	1450	95
Aliphatic Chemicals								
Formaldehyde (100%)	950	1000	502	646	550	750	850	96
Acetaldehyde	1200	1300	900	950	925	975	1025	90
Methanol	2200	2300	1435	1790	1500	1900	2100	99
Ethanol	2800	2900	1630	1690[4]	1650	1800	1900	93
Iso-Propanol	1250	1300	1029	1126	1075	1200	1250	100
Butanols	650	700	505	546	525	600	650	70
Ethylene Oxide	1600	1700	1051	1395	1300	1500	1600	96
Ethylene Glycol	1800	1900	1145	1215	1175	1300	1350	92
Propylene Oxide	300	330	....	288	....	300	330	100
Propylene Glycol	200	250	....	152	....	170	220	100
Glycerol	430	500	210	240	230	260	290	50
Acrylonitrile	390	420	178	232	230	260	300	100
Acetic Acid	950	1050	566	649	600	750	800	98
Acetic Anhydride	1150	1250	965	1097	1000	1150	1250	98
Acetone	850	950	611	736	630	780	850	83
Methyl Ethyl Ketone	220	260	....	200	....	235	260	100
Maleic Anhydride	128	250	....	61	....	100	150	0
Dichloromethane	....	....	....	113	....	125	150	100
Carbon Tetrachloride	375	450	313	369	325	400	450	85
Ethyl Chloride	....	....	536	551	550	600	650	....
Ethylene Dichloride	....	....	773	1140	775	1200	1250	....
Trichloroethylene	....	....	295	360	320	400	440	....
Perchloroethylene	....	....	187	203	220	225	245	....
Fluorocarbons	480	530	....	246[5]	....	250	300	100
Vinyl Chloride	1000	1100	691	978	720	1050	1100	....
Vinyl Acetate	330	380	190	244	210	275	300	....
Aromatic Chemicals								
Chlorobenzene	....	....	....	562	....	600	650	60
Nitrobenzene	....	....	....	172	....	190	210	60
Phthalic Anhydride	....	....	....	358	....	390	430	0

* Total capacity and production—petrochemical and other sources.

creased appreciably in price. The sharp drop in acrylonitrile reflects major expansions of production capacity, at a time when consumption increases have been disappointing. Other price decreases result from moderate over-supply situations (acetone), lower cost production from new facilities (butadiene), or competition from other materials or sources (vinyl acetate, xylene).

PETROCHEMICAL CAPACITY ESTIMATES

Most capacity increases during the past year have been moderate, with some stemming from modification of and additions to existing plant facilities. For several growing petrochemical products, new plants have been constructed, and many are scheduled for completion in 1961. Estimates are listed in Table 2.

Olefins. Ethylene capacity should continue to grow, but only by a moderate amount in 1961. The big jump is coming in propylene capacity—now the most rapidly growing olefin. Butylene and butadiene capacities are expected to show only a slight gain.

Aromatics. Benzene, toluene and xylene plant capacities should increase only about 10-15 percent in 1961. A newcomer to the petrochemical lists, napthalene, had negligible capacity in 1960, but several new plants should be on stream in 1961. This is a case where decreasing natural production (from coke-oven operations) has required production from petrochemical sources.

Polymers. Polyethylene capacity took a major spurt in 1959-60, and will show more growth in 1961. The proportionately greater increase in polypropylene capacity is indicative of the promise of this relative new-comer. Synthetic rubber capacity will take a major jump by

1961, as facilities for the new "synthetic natural rubber" come on stream.

Phenol. Petrochemical phenol capacity will increase moderately, to compensate for reduced availability of the natural (coke-oven) product. Capacity for the natural product is not included in the figures in Table 2.

Ammonia. Capacity increase has been and will be only moderate for this product, which still suffers from overcapacity pains.

Urea. After major expansions in 1959-60, urea capacity will be increased only moderately in 1961, as there is substantial excess capacity available.

Aliphatic Chemicals. Plant capacity increases for these products have been and will be in most cases only moderate in 1961. Substantial increases for ethylene oxide and glycol, propylene oxide and glycol, and acetic acid and anhydride reflect new growth in requirements for these products.

Aromatic Chemicals. Newly listed in these reports, these are mainly products made in existing plants, from aromatic base materials coming from both petrochemical and non-petrochemical sources (coke-ovens). As the latter decreases, we may expect to see new facilities added as part of petrochemical complexes, but such growth has not yet occurred.

PRODUCTION

Final production figures for 1959 substantially exceeded estimates for that year. In essence, the major increase in 1959 counter-balanced the substantial drop below estimates for 1958. Production in 1960 has shown continued growth, but not at as high a rate of increase as 1959. A further steady increase in production of petrochemicals is estimated for 1961.

Aliphatic Hydrocarbon Intermediates. Ethylene, production of which came close to 5,000 million pounds in 1959, should increase steadily to 5,300 million pounds in 1960 and about 5,600 million pounds in 1961, continuing its lead as the key petrochemical intermediate. Propylene should show a similar steady growth from 2,516 to 2,800 to 3,100 million pounds in 1959, 1960 and 1961. A more moderate increase in butylene production from 2,144 to 2,300 and 2,500 million pounds is expected over the same period. Butadiene, having taken a major jump to 1,816 million pounds production in 1959, should increase moderately to 2,000 and 2,100 million pounds in 1960 and 1961. Acetylene production increases, still below earlier anticipations, should continue, from 815 million pounds reported in 1959 to 875 and 950 million pounds in 1960 and 1961, respectively.

Aromatic Hydrocarbon Intermediates. With a continuing increase in the proportion from petrochemical sources, aromatic intermediates show further production gains. Benzene, with the greatest gain in the group, to 2,540 million pounds in 1959, should go to 2,700 million pounds in 1960 and 2,900 million pounds in 1961. Apparent excess capacity is mainly in coke-oven facilities, which are being utilized less and less with decrease in coke demand. Toluene, with 2,030 million pounds production in 1959, is estimated to increase to 2,200 and 2,400 million pounds in 1960 and 1961. Xylene production of 1,770 million pounds in 1959 should grow in output to 1,900 million pounds in 1960 and 2,100 million pounds in 1961. Styrene output jumped to 1,571 million pounds in 1959, and is estimated to reach 1,700 million pounds in 1960 and 1,800 million pounds in 1961. Naphthalene, newly listed as a petrochemical, was produced at the rate of 425 million pounds per year in 1959. Growth is estimated to 450 and 550 million pounds per year in 1960 and 1961 respectively, with most of the increased output coming from new petrochemical facilities.

Newly listed, but long-established petrochemical products are: cyclohexane, amounting to 388 million pounds in 1959; Dodecylbenzene, 530 million pounds in the same year; and ethylbenzene with an output of 1,422 million pounds that year. All of these should show production increases of about 5 percent per year in 1960 and 1961.

Hydrocarbon Polymers. Of a polyethylene production of 1,195 million pounds in 1959, better than 85 percent came from high-pressure processes. Further growth, particularly in the low-pressure process product, should increase output to 1,350 million pounds in 1960 and 1,500 million pounds in 1961. Polypropylene, now the rapidly growing newcomer, showed a production of only 20 million pounds in 1959. With new facilities coming on stream, it is estimated that about 50 million pounds will be produced in 1960, and 100 million pounds in 1961. Synthetic rubber production jumped to 2,825 million pounds in 1961, and with new higher-quality production augmented, should reach 3,000 and 3,200 million pounds in 1960 and 1961, respectively.

Phenol. Now obtained mainly from petrochemical sources, phenol output should reach 750 million pounds in 1960 and 800 million pounds in 1961, after having reached a new high in production of 692 million pounds in 1959.

Ammonia. Though still in over-supply, the 1959 output of 8,800 million pounds utilized more than 80 percent of existing capacity. Substantial increases to 9,600 million pounds in 1960 and 10,200 million pounds in

1961 are estimated, tending to narrow the gap between capacity and production, despite new facilities to come on stream in 1961.

Urea. After a major round of new plant construction, urea output reached 1,261 million pounds in 1959. This should increase to 1,350 million and 1,450 million pounds per year in 1960 and 1961, still leaving substantial over-capacity.

Aliphatic Chemicals. Major increase of 20 percent or more in 1959 production to 646 million pounds of formaldehyde, 1,790 million pounds of methanol, 1,395 million pounds of ethylene oxide, 232 million pounds of acrylonitrile, 649 million pounds of acetic acid, 736 million pounds of acetone, 369 million pounds of carbon tetrachloride, 1,140 million pounds of ethylene dichloride, 360 million pounds of trichloroethylene, 978 million pounds of vinyl chloride and 246 million pounds of fluorocarbons, should be followed by proportionately smaller, but still substantial, increases in output for 1960 and 1961.

More moderate increases for other products in this group in 1959, to 950 million pounds of acetaldehyde, 1,690 million pounds of ethanol, 1,126 million pounds of iso-propanol, 546 million pounds of butanol, 1,215 million pounds of ethylene glycol, 240 million pounds of glycerol, 1,097 million pounds of acetic anhydride, 551 million pounds of ethyl chloride, 203 million pounds of perchloroethylene and 244 million pounds of vinyl acetate, should be followed with continued modest growth in production in 1960 and 1961.

Several newly listed products in this group should show substantial increases in 1960 and 1961 output, from 1959 production of 288 million pounds for propylene oxide, 152 million pounds for propylene glycol, 235 million pounds for methyl ethyl ketone, 250 million pounds for maleic anhydride (soon to be made from petrochemical sources) and 113 million pounds for dichloromethane.

Aromatic Chemicals. Also newly listed, these products are now, or soon will be, produced from petrochemical sources. Chlorobenzene, reaching 562 million pounds output in 1959 should increase to 600 and 650 million pounds in 1960 and 1961. Nitrobenzene production of 172 million pounds in 1959 should grow moderately to 190 and 210 million pounds in 1960 and 1961. Phthalic anhydride manufacture of 358 million pounds in 1959 is estimated to grow through new petrochemical routes to 390 million and 430 million pounds in 1960 and 1961.

EXPANSION PLANNING

A new surge of petrochemical product demand has already started, and may be expected to continue for several years. Emphasis will be on somewhat different products than those which have experienced the greatest growth in recent years.

Refined propylene demand will grow rapidly, and the capacity requirements for this product may exceed ethylene in a few years. Moderate increases in ethylene, butylene and butadiene capacity will be required. Petrochemical acetylene should undergo a new advance in the near future.

Although some aromatics appear to have ample production capacities, much of this is related to idle coke-ovens. More BTX installations are indicated within two or three years. New petrochemical naphthalene facilities have been announced. If these are successful, substantial additional installations will be indicated to replace coke-oven supplies.

Synthetic phenol may be tight within two years. Ammonia, however, will still be in ample supply. Urea shows excess capacity which may persist for a few years.

Methanol is due for another round of expansion. Synthetic ethanol production is tight, and with the indefinite nature of fermentation molasses supplies, additional petrochemical ethanol capacity is required. Isopropanol and butanol capacity expansion is also indicated.

Chlorinated compounds such as carbon tetrachloride, vinyl chloride and ethylene chloride may also require expanded production facilities.

Early planning and construction can pay off in meeting growing petrochemical market demands in 1962 and 1963.

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About the Author

Dr. Raphael Katzen graduated from Polytechnic Institute of Brooklyn in 1936 with a B.S. degree in Chemical engineering, then received his M.S. degree in 1938 and his Ph.D. degree in 1942, both in chemical engineering from the same school. He gained a great deal of technical experience by working for Cellutate Inc., Northwood Chemical Company, Diamond Alkali, Inc., and Vulcan-Cincinnati, Inc. In 1953 he started practice as a Consulting Engineer. Early in 1956 Dr. Katzen organized Raphael Katzen Associates International, Inc., which consists of a group of consulting engineers and scientists engaging in consulting activities in petrochemicals and organic chemicals from Canada to Latin America. Presently he is president of this firm which is located in Cincinnati, Ohio.

Katzen

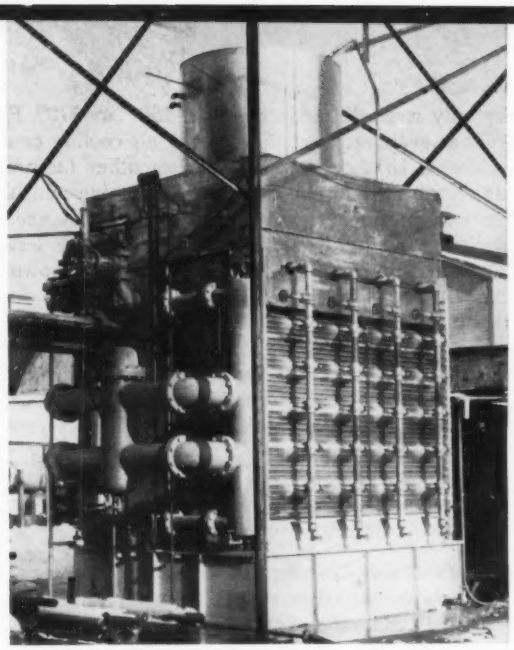


FIGURE 1—Evaporative cooled heat exchanger is in service as vacuum steam condenser. It contains 1,500 square feet of surface and handles 3,490 pounds of steam per hour at 2.0 inches mercury absolute pressure. Ambient wet bulb temperature is 70° F.

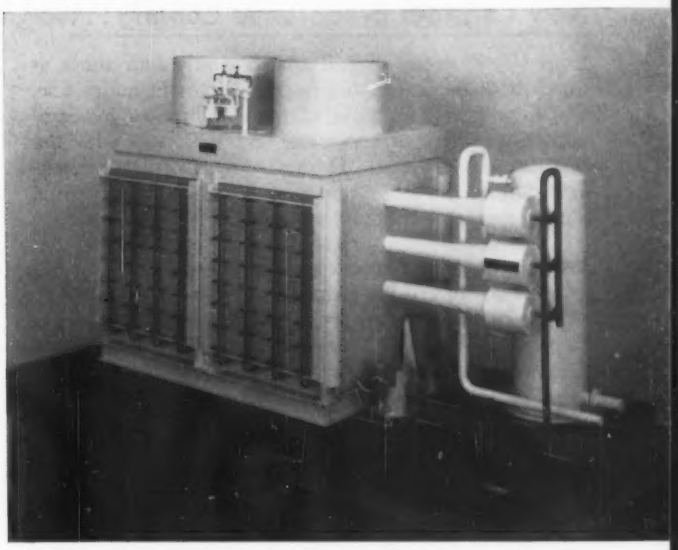


FIGURE 2—This twin cell evaporative cooled steam condenser services a steam vacuum refrigeration system for producing 45° F chilled water. The flash tank and three booster ejectors are shown on the right.

Now Consider Evaporative Cooling

Evaporatively cooled heat exchangers can sometimes be better than air cooling or designs requiring a cooling tower. Look over these applications and advantages

F. Duncan Berkeley, Graham Manufacturing Co., Inc., Batavia, N. Y.

EVAPORATIVE COOLERS in many applications give greater heat transfer than air coolers. The evaporative equipment can do this by offering a lower temperature heat sink. Furthermore, the evaporative cooler can also have advantages over a design requiring a cooling tower.

WHAT IS EVAPORATIVE COOLING

To one not familiar with evaporative cooled exchangers perhaps the best description for this type of equipment would be to say that it is a combination shell and tube heat exchanger and cooling tower built into a single package. Some of the designs of evaporative cooled exchangers currently available today are shown in Figures 1 and 2. The tube surfaces are cooled by evaporation of water into the air.

A recirculating pump draws water from the basin under the unit and pumps it through a system of sprays (or water distributors) from which the water is directed onto the tube surfaces. Air is induced or forced over the wetted tube surfaces and through the rain of water droplets. By intimate contact of the air with the wetted tube surfaces and water droplets evaporation of part of the water occurs thus cooling both the tube surfaces and the water simultaneously. In this manner evaporation is used to increase the rate of heat transfer from the tubes to the air.

COMPARE WITH DRY AIR COOLING

Air cooled heat exchangers have received widespread interest lately because of the necessity for conserving water in some industrial locations. Many excellent articles[1-8] have discussed air cooled heat exchangers and practically every phase of this subject has been discussed with one large and important exception; that is, evaporative condensers and heat exchangers.

The lack of published information on evaporative cooling has deterred the use of this means of cooling. However, the facts about this subject are becoming better known and the result is a trend to greater popularity.

The increase in heat transfer rate over dry air cooling is considerable and the efficiency of evaporative cooling over dry air cooling is much higher. For example; a given weight of air increasing in temperature

from 60° F to 90° F will absorb nearly four times as much heat in an evaporative process as in a dry one. See Figure 3. This ratio of heat absorption increases with higher temperature rises and will vary with the temperature of the air. The water is, of course, recirculated within the unit while the moisture ladened heated air is expelled to the outdoors.

When to Use Evaporative Cooling. Perhaps the greatest advantage the evaporative cooler can offer over dry air cooling is a lower temperature heat sink. In dry air cooling the heat transferred per pound of air is dependent upon the allowable temperature rise of the air. The use of water cooled exchangers in series with an air cooled exchanger becomes necessary when the process heat must be removed at temperatures below 150° F.

It has been suggested[7] that if approximately 75 percent of the process heat can be removed above 150° F, dry air cooling should be considered. It is significant to note that with the exception of a small overlap in operating temperatures the evaporative cooler can take over where dry air cooling must drop out of the picture. The evaporative cooler has limited use for process temperatures above 170° F due to high tube wall temperature causing a more rapid build up of scale on the wetted surface of the tubes.

The evaporation rate at 115° F is sufficiently high to form a soft scale on the tubes, unless the recirculating water has an unusually low amount of impurities. If the recirculating water temperature does not exceed 115° F the deposit on the tubes will usually be soft enough so that most of it washes off the tubes as fast as it forms. As the recirculating water temperature increases above 115° F the rate of scale deposit will increase and the hardness of the scale will increase.

At recirculating water temperatures above 150° F the rate of scale deposit and hardness of the scale can be too high to be tolerated for some applications unless extra precautions are made to treat the make-up water or increase the blow rate to reduce the hardness of the recirculating water. Table 1 will serve as a rough guide to various make up and recirculating water conditions.

When viscous fluids or gases are cooled, the heat transfer film rate may be sufficiently low so that the recirculating water and tube wall temperatures will be below 150° F and 170° F, respectively, even though the fluid inlet temperature is well above these temperatures. It is also possible to reduce the recirculating water and tube wall temperatures by increasing the air flow. The fan bhp will be increased accordingly, however.

In most cases, therefore, the evaporative cooled heat exchanger has its field well defined at process temperatures between 170° F maximum down to about 10° F above the design wet bulb temperature of the ambient air. The 170° F temperature limit can be extended to higher temperatures by using treated or pure makeup water. In the case of steam condensers, which are evaporatively cooled, the condensate is frequently available as a source of pure make-up water.

If we consider that for most cases the process temperature limit for evaporative cooling is 170° F then there is only a small range between 150° to 170° F where either evaporative cooling or dry air cooling can be considered. In these borderline cases other factors peculiar to the installation will often determine which of these two possibilities should be given preference. Evaporative cooled units will, of course, require less surface and less air than dry air cooled units, as shown in Table 2.

In many cases the combination of a dry air cooled and an evaporative cooled exchanger will be the best solution to the situation. In this case the dry air cooled surface can be very neatly incorporated into the same unit with the evaporative cooler. The dry surface can reduce the process temperature to say 150° F at which point the evaporative or wetted surface can accomplish the remaining part of the duty. The same fan serves both sections of the heat exchanger.

Advantages Over Conventional Cooling Towers. Comparing the evaporative cooled exchanger to a cooling tower-shell and tube exchanger combination there are several basic advantages to the evaporative cooled exchanger. First of all, lower process temperatures are obtainable by combining two steps of heat transfer into one, thereby utilizing the maximum possible temperature difference between the process temperature and the prevailing wet bulb temperature.

For example, in a cooling tower-shell and tube steam condenser combination, the cooling tower cools the water down to within about 7 to 15° F of the prevailing wet bulb temperature. If the wet bulb temperature is, say, 75° F the water may be cooled to about 85° F. Similarly in the condenser a temperature difference must also be maintained as a driving force for the heat transfer. With a 15-degree rise on the cooling water through the shell and tube condenser the minimum condensing temperature would be limited to about 5° above the outlet water temperature or in this case 105° F (2.24″ Hg Abs). With a condenser that is evaporatively cooled, however, the condensing temperature could be easily within 15° F of the prevailing wet bulb temperature, or in this case 95° F (1.66″ Hg Abs), 10 degrees lower than with the cooling tower and water cooled heat exchanger.

The advantages offered by the evaporative cooled condenser is, of course, dependent upon the ability of the cooler to raise the temperature and humidity of the cooling air to the highest possible point consistent with cost. It would be false economy to achieve the last few degrees of temperature rise at the expense of a disproportionate rise in the cost of the equipment and its operating cost. The example cited here is merely typical of the lower process temperatures that can be achieved with evaporative cooled condensers as compared to a cooling tower and water cooled condensers. One must consider the size of the installation as well as other factors for each case to accurately assess the merits of each system.

Some of the other considerations are:

- Pumping costs of each system
- Packaged construction advantages
- Space requirements
- Piping costs of each system (process and water piping)
- Installation costs.

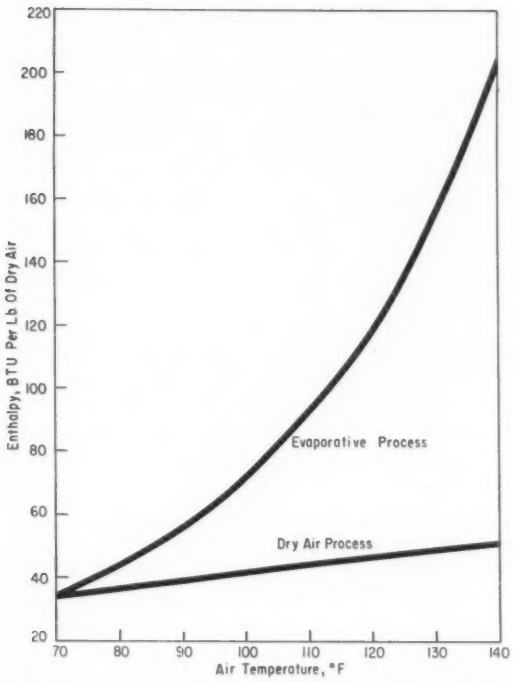


FIGURE 3—For an initial wet bulb temperature of 70° F, here is how evaporative cooling compares with dry air cooling.

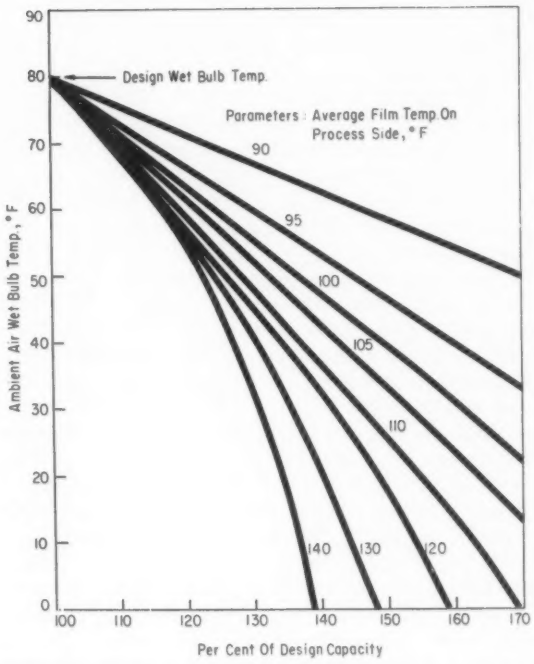


FIGURE 4—Typical performance for an evaporatively cooled heat exchanger with constant-speed fixed-pitch induced-flow fan.

KEEP THESE DESIGN CONDITIONS IN MIND

Since the performance of an evaporative cooled heat exchanger depends entirely upon the ambient wet bulb temperature and air density, only the maximum wet bulb temperature and approximate altitude of the installation site are required to determine the surface and fan size for a particular heat exchanger duty. Accepted design wet bulb temperatures for many applications are usually set at a figure which will be exceeded only 5 percent of the total hours during June to September inclusive. There are, however, a few applications where the process temperature is critical enough to warrant designing the unit for a wet bulb temperature that will not be exceeded more than 1 percent of the hours during June to September. With the advent of controllable pitch fans and carefully engineered equipment the extra cost for these high wet bulb temperature designs has had some of the sting taken out of them. By merely increasing the air flow through an evaporative heat exchanger it is possible to increase its capacity.

Fan Horsepower. In designing a large industrial unit the design engineer must keep an eye on both the initial equipment cost and the operating costs in order to come up with a practical design. In doing so, therefore, he uses all the fan horsepower he can at the design wet bulb temperature to reduce both the amount of cooling surface required and the initial equipment cost, but at the same time, he does not exceed a fan horsepower that will make the operating cost of his design unduly high. There is, therefore, always a little more air flow available at an increased operating cost, if the unit is furnished with a controllable pitch fan and a sufficiently large motor to handle the extra air horsepower. A multispeed fan motor or a steam turbine driven fan will also provide control on the air flow. For those few hours of the year when the wet bulb temperature exceeds the normal design wet bulb temperature, the controllable pitch fan, multispeed motor or turbine drive can boost the air flow to meet these extreme conditions without sacrificing all the economy of purchasing equipment that is designed for a normal maximum wet bulb temperature. The extra cost for a controllable pitch fan with a slightly higher horsepower motor will be approximately $1,700 for most applications. Compare this to increasing the design wet bulb temperature from, say 72° F to 80° F, to include the highest wet bulb temperature on record for the particular locality in question. The increase in design wet bulb temperature would increase the surface anywhere from 6 to 15 percent which could result in several thousand dollars additional cost on a large unit.

An excellent example of an application with high design wet bulb temperature is a condenser for a steam vacuum refrigeration unit furnishing chilled water for air conditioning. In this case the equipment must handle its maximum heat load during the hottest and most humid time of the year. If the condenser fails to produce the correct pressure, due to an unusually high wet bulb temperature, the boosters will fail to operate properly and the air conditioning system will not cool. With a controllable pitch fan, multispeed motor or turbine fan drive, however, the condenser could handle the higher wet bulb condition with a temporary sacrifice in operating economy. This condition may occur only one day out of the year for three or four hours so it would be difficult to justify purchasing a larger condenser at several thousand dollars extra cost, but

$1,700 for the controllable pitch fan is not unreasonable.

The controllable air flow also has a much more frequent advantage than just described. The power savings on a large installation will be quite substantial if the fan thruput and horsepower can be reduced by varying the pitch of the blades or reducing the fan speed during those times of the year when the wet bulb temperature or heat load is below the design condition.

As the ambient wet bulb temperature drops, the capacity of the evaporative cooler increases. The variation in heat capacity for various wet bulb temperatures at various process temperatures is shown in Figure 4 for a typical unit operating with an induced draft fan having a constant volume rating. With a controllable pitch or variable-speed fan it is important to compare the average power consumption of the fan to the constant power requirement for a fixed pitch fan, since the maximum power for the controllable fan may occur for only 1 percent of the total annual operating time.

Another advantage of the controllable fan is that it provides an excellent means of preventing freezing during winter months. While the air flow can also be regulated by means of shutters or dampers to prevent freezing and provide control over the process temperatures, this method of control will not reduce the power consumption of the fan to any appreciable extent. In some designs, however, it may be necessary to use shutters where several heat exchangers are combined in one large unit and it is necessary to control the air flow through various sections of the unit. If complete shut down is necessary during cold weather the evaporative cooler can be designed to provide complete and rapid drainage. The few drainage points required can be opened either electrically or pneumatically from a remote location so as to facilitate shutdowns if the process is intermittant. If the shut downs occur for only a few hours a small electric or steam heater strategically located in the recirculating water basin will provide economical and convenient freeze protection for short periods.

Water Requirements. Aside from the initial charge of water to fill the basin only a small quantity of make-up water is required to maintain the evaporative cooling cycle. This make-up water is determined by the amount of water that is lost from the system due to:

- Evaporation — Approximately ¾ lb. per 1000 Btu of cooling duty.
- Blowdown—Depends on several factors—allow for ¾ lb. per 1000 Btu.
- Drift Losses—very small in properly designed unit.

The evaporation rate is dependent upon the temperature of the recirculating water and the temperature of the air at the inlet and exit of the cooler. The recirculating water temperature will vary between 90° F and 150° F depending upon the process temperatures to be maintained. The latent heat of the water will, therefore, vary between 1042.9 and 1002.3 Btu/hr. The latent heat of evaporation accounts for most of the heat that is dissipated. The sensible heating of the air will account for some additional heat dissipation. By referring to a psychrometric chart the enthalpy change of the air will permit one to determine the change in absolute humidity per pound of dry air. By multiplying the dry air flow by the change in absolute humidity per pound of dry air, the exact rate of evaporation in lbs/hr. can be determined.

The blowdown rate is dependent upon several factors, namely; the purity of the make-up water, the impurities added to the water from the air, and the purity to be maintained in the recirculating water.

As the impurities in the recirculating water become concentrated due to the evaporation process, some of the recirculated water must be drained off, either intermittently or continuously, in order to maintain a reasonably low level of impurities in the system. Additional impurities will be added to the system due to pollens, dust, smoke and vapors from the ambient air that are drawn or blown through the system. The air borne impurities are difficult to predict, but normally do not represent a large portion of the impurities that are brought into the system. The air borne impurities are, therefore, usually brought under control by adjusting the blow down rate after the unit is in operation.

The drift losses are small in a properly designed unit. A generous plenum chamber and a mist eliminator similar to that in a cooling tower can reduce the entrainment of liquid particles to an imperceptable rate.

The three factors mentioned above, though general are fairly typical for most applications and for estimating purposes one can figure on about 1.5 pounds of make-up water for every 1,000 Btu's of heat to be dissipated where the impurities in the make-up water

TABLE 1—How To Judge Water Hardness

Hardness, PPM	General Classification
Less than 10 PPM	Very Soft
10 to 50 PPM	Moderately Soft
50 to 150 PPM	Moderately Hard
150 to 250 PPM	Hard
250 to 500 PPM	Very Hard
Over 500 PPM	Extremely Hard

TABLE 2—Comparison Of Dry Air Cooled Condenser And Evaporative Condenser For Turbine Steam Condensing Service

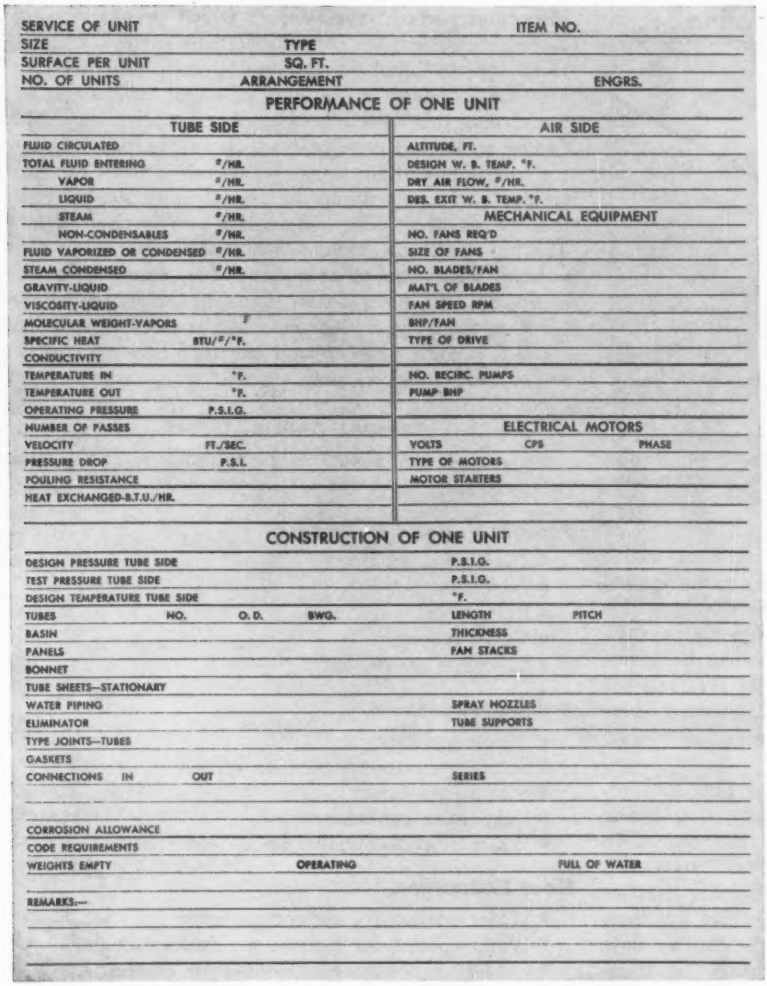
	Dry Air Cooling	Evaporative Cooling
B.H.P. Required		
Fan	38.8	7.5
Recirc. Pump	0.	4.5
Total	38.8	12.0
Space Required	28′ x 21′	14′ x 10′
Tube Surface		
Sq. Ft. Bare	3,980	2,110
Sq. Ft. Total	66,404	2,110
Press. Drop Tube side, In. Hg.	1.38	.50
Tube Size	1″ x 18 BWG x 30′	¾″ x 18 BWG x 12′
Type of Tubes	2¼″ O.D. Fins	Bare Tubes
Air Flow Req'd. #/Hr.	1,520,000	160,500
*Approximate Price	$29,800	$25,600

DESIGN CONDITIONS:
Steam Condensed: 14,300 #/hr.
Pressure @ Steam Inlet: 7.57″ Hg. Abs. (22.43″ Hg. Vac.)
Steam Saturation Temp. @ Inlet to Condenser: 150 °F.
Design Dry Bulb Temperature: 90 °F.
Design Wet Bulb Temperature: 70 °F.

* Prices are net F.O.B. Manufacturer's Plants. Price of Dry Air Cooled Condenser does not include Steam Jet Air Ejector, Condensate Hotwell nor Condensate Pump while evaporative condenser price includes all of the acces sories.

TABLE 3—Materials of Construction

Part	Standard	Special
Process Side		
Tubes	Admiralty	To Suit
Tube Sheets	Steel	To Suit
Bonnets	Steel	To Suit
Fluid Inlet	Steel	To Suit
Fluid Outlet	Steel	To Suit
Air Side		
Tube Supports	Steel	Aluminum
Water Basin	Steel (Coated Inside)	Aluminum
Eliminator	Galvanized Steel	Aluminum
Water Piping	Galvanized Steel	Aluminum
Panels	Galvanized Steel	Aluminum
Fan Stack (S)	Galvanized Steel	Aluminum
Fan Blades	Aluminum	Aluminum
Structural Parts	Steel	Aluminum
Bolting	Steel	Cadmium Plated
Spray Nozzles	Brass	Nickel Plated



SERVICE OF UNIT — ITEM NO.
SIZE — TYPE
SURFACE PER UNIT — SQ. FT.
NO. OF UNITS — ARRANGEMENT — ENGRS.

PERFORMANCE OF ONE UNIT

TUBE SIDE		AIR SIDE	
FLUID CIRCULATED		ALTITUDE, FT.	
TOTAL FLUID ENTERING	#/HR.	DESIGN W. B. TEMP. °F.	
VAPOR	#/HR.	DRY AIR FLOW, #/HR.	
LIQUID	#/HR.	DES. EXIT W. B. TEMP. °F.	
STEAM	#/HR.	MECHANICAL EQUIPMENT	
NON-CONDENSABLES	#/HR.	NO. FANS REQ'D	
FLUID VAPORIZED OR CONDENSED	#/HR.	SIZE OF FANS	
STEAM CONDENSED	#/HR.	NO. BLADES/FAN	
GRAVITY-LIQUID		MAT'L OF BLADES	
VISCOSITY-LIQUID		FAN SPEED RPM	
MOLECULAR WEIGHT-VAPORS	#	BHP/FAN	
SPECIFIC HEAT	BTU/#/°F.	TYPE OF DRIVE	
CONDUCTIVITY			
TEMPERATURE IN	°F.	NO. RECIRC. PUMPS	
TEMPERATURE OUT	°F.	PUMP BHP	
OPERATING PRESSURE	P.S.I.G.		
NUMBER OF PASSES		ELECTRICAL MOTORS	
VELOCITY	FT./SEC.	VOLTS CPS PHASE	
PRESSURE DROP	P.S.I.	TYPE OF MOTORS	
FOULING RESISTANCE		MOTOR STARTERS	
HEAT EXCHANGED-B.T.U./HR.			

CONSTRUCTION OF ONE UNIT

DESIGN PRESSURE TUBE SIDE				P.S.I.G.	
TEST PRESSURE TUBE SIDE				P.S.I.G.	
DESIGN TEMPERATURE TUBE SIDE				°F.	
TUBES	NO.	O. D.	BWG.	LENGTH	PITCH
BASIN				THICKNESS	
PANELS				FAN STACKS	
BONNET					
TUBE SHEETS—STATIONARY					
WATER PIPING				SPRAY NOZZLES	
ELIMINATOR				TUBE SUPPORTS	
TYPE JOINTS—TUBES					
GASKETS					
CONNECTIONS IN	OUT			SERIES	
CORROSION ALLOWANCE					
CODE REQUIREMENTS					
WEIGHTS EMPTY		OPERATING		FULL OF WATER	

REMARKS:—

FIGURE 5—This specification sheet will help you get what you need when you specify evaporatively cooled heat exchangers and condensers.

and air are not usually high. If we assume a 15° F rise for cooling water in a shell and tube heat exchanger then an evaporative cooler would require less than 3 percent of the water required for the shell and tube unit on a "once-through" basis. In addition to the drastic reduction in water requirements, pumping costs, water piping costs and conservation of sewer capacity are also important considerations for heat exchanger installations.

MATERIALS OF CONSTRUCTION AND DESIGN FEATURES

Evaporative cooled heat exchangers are available in any of the materials normally used for heat exchangers. Normally, only the materials on the process side of the exchanger need be altered to suit a particular application since the air side will almost always be subjected to the usual corrosion encountered with air and water. The process side can be therefore, steel, stainless steel, copper, nickel, nickel-chrome alloy, aluminum, aluminum alloy, cupro-nickel, admiralty, lead, carbon or a number of other materials commonly used for heat exchangers.

On the air side it is possible to prolong the life of the unit by using aluminum which is more resistant to normal atmospheric corrosion than steel. The list of materials in Table 3 refers to the construction of evaporative heat exchangers as shown in Figures 1 and 2. This list indicates where aluminum can be used to good advantage in the construction of the unit, the aluminum construction being only slightly more in cost.

Special precautions are taken with aluminum to prevent contact with steel brass or any other metals that would produce galvanic corrosion. It is important, therefore, to keep the air side materials either standard or all aluminum.

Standard designs utilize either ¾" or 1" OD 18 BWG tubes in any even numbered tube lengths from 8 feet to 20 feet. Tube lengths over 20 feet may be practical provided the cost of the longer water basin does not offset the savings resulting from the longer tube length. In combined dry and wetted surface construction the dry air cooled section will utilize either low or high finned tubes to produce additional surface per foot of tube length. With dry air cooling, finned tubes will yield substantial savings over bare tubes. In the wetted sections, bare or low finned tubes are used. Preliminary testing of low finned tubes for evaporative coolers indicate that scale deposits on low fins present no serious problems. Considerable extra surface can be obtained with the low fins. For cooling viscous fluids low finned tubing is recommended while for some non-viscous fluids and particularly vacuum steam condensing bare tubes appear to be more practical because of the higher pressure drop in the smaller flow area of the low finned tubes.

For evaporatively cooled heat exchangers, all of the details needed for specifying a service are shown in Figure 5.

OPERATING COSTS AND MAINTENANCE

The operating costs for evaporative condensers are normally less than a cooling tower designed to dissipate the same heat load. This is generally true because the air flow for evaporative condensers will be about equal for equivalent service and the recirculating water pumping cost will usually be less.

The fan static pressure for the evaporative cooler will usually be between 0.2 inch and 0.8 inch of water which is also true for the cooling tower. Comparison of brake horsepower requirements for equivalent service indicate that the evaporative cooler will generally be equal to or lower than the cooling tower.

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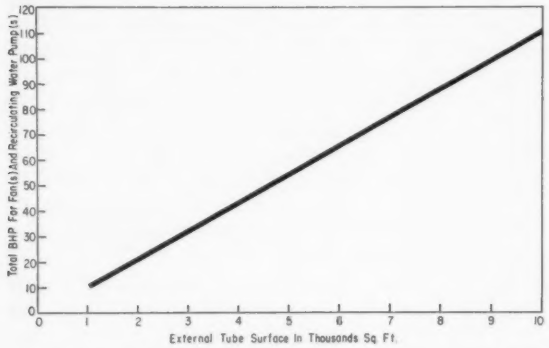

FIGURE 6—Typical maximum horsepower requirements for evaporatively cooled exchangers. By increasing the cooling surface in a particular application the fan power requirements can be reduced to some suitable level.

The rate of recirculating water in an evaporative cooler is less than half of the recirculating rate required for a cooling tower-exchanger combination designed for equivalent service. The total pressure drop through the spray system in the evaporative cooler will be about 30 feet which is generally less than that required for the water circuit of a cooling tower-exchanger combination, particularly if the cooling tower must be located any distance from the heat exchanger.

Typical fan and recirculating pump bhp requirements for evaporative condensers used for condensing steam or cooling non-viscous liquids are shown in Figure 6. For cooling of viscous liquids and fluids with inherently low heat transfer film coefficients the fan horsepower requirements will be considerably less than indicated by Figure 6, since there will be less air flow required per square feet of tube surface in these applications.

Maintenance requirements for evaporative coolers are comparable with shell and tube heat exchangers. If proper fouling resistances are used to determine the cooling surface, the frequency of cleaning can be reduced to practically any level desired. A few designs permit visual inspection of the external tube surface without shutting down the unit. Even cleaning of the outside tube surface can be accomplished either chemically or mechanically without shutting down the unit. Tube side inspection can be accomplished through inspection ports in the bonnets which permit viewing a section of the tubes throughout their entire length by removing the blind flanges on the inspection ports of opposing bonnets. In the case of vapor condensing or gas cooling it is sometimes possible to replace the blind flanges with glass or plastic which will permit viewing the tube side without shutting the unit down. Cleaning of the basin and pump suction strainer are recommended at those times when the unit is shut down. The fan and recirculating water pump require only the normal maintenance procedures for these types of equipment. In general, the maintenance requirements for evaporatively cooled heat exchangers are about equal to a cooling tower-shell and tube heat exchanger combination for equivalent service.

TYPICAL APPLICATIONS

Some typical applications for evaporative cooled exchangers are:

Process Vapor Condensers.

- Distillation towers
- Deodorizers
- Refrigerant condensers
- Vapor recovery
- Glycerine condensers

Steam Condensers.

- Steam turbines
- Steam vacuum refrigeration systems
- Steam jet ejectors
- Evaporator condensers
- Waste or contaminated steam condensers

Heat Exchanger.

- Water cooling for air compressors
- Water cooling for internal combustion engines
- Oil coolers for internal combustion engines
- Transformer oil coolers
- Compressor discharge gas cooling

Because of the relatively small sizes of evaporative cooled exchangers as compared to dry air cooled units, indoor or semi-indoor installations are often practical in addition to the usual outdoor installations. If the indoor installation can be made adjacent to a wall, the air intake and discharge can be easily made through the wall. For architectural purposes, as in the case of an office building, it may be desirable to conceal the unit by installing it under the roof of the building allowing for louvered air intakes and exhaust openings.

About the Author

F. Duncan Berkeley is the research and development director for Graham Manufacturing Co., Inc., Batavia, N.Y. A graduate of Rensselaer Polytechnic Institute with a B.M.E. degree, he has been with Graham since 1950. Mr. Berkeley has published several articles on ejectors and related equipment and is a member of the ASME and AIChE. He has been working for the past two years in the design and development of evaporatively cooled heat exchangers for industrial use.

Berkeley

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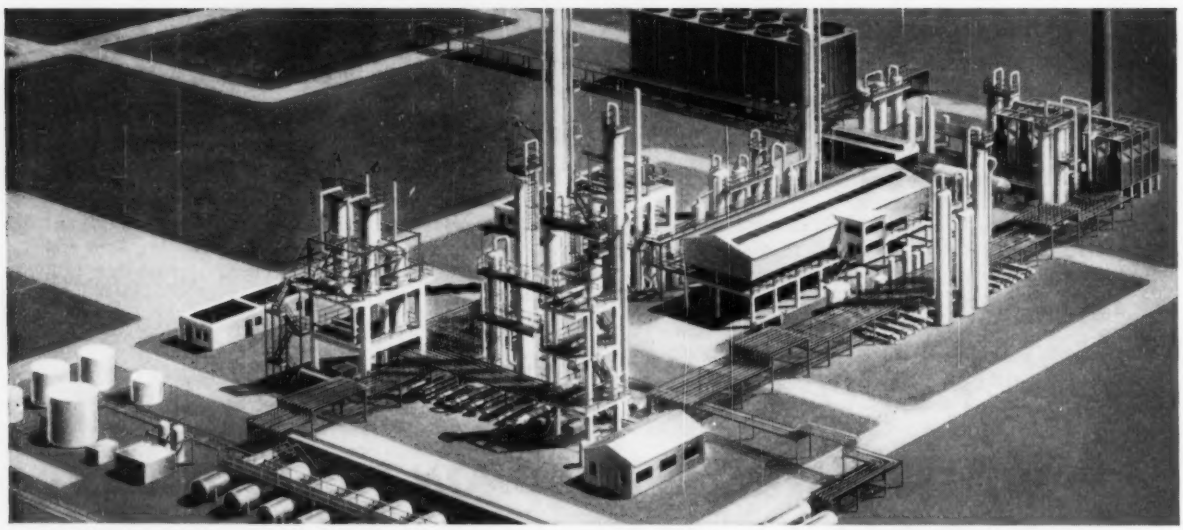

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The plant is scheduled to go on stream late in 1961, and will have a design capacity of 225,000,000 lbs. of ethylene and 55,000,000 lbs. of ethylene oxide per year. Existing facilities will be modified to permit production of 12,000,000 cubic feet of high-purity hydrogen and up to 1,000,000 cubic feet of carbon monoxide per day.

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Portrait of the Chief Executive

People harbor many false ideas about the chief executive. This timely article reveals the real man behind the desk—his needs, responsibilities, and what it takes to make him hit on all cylinders

David Tver
Petty Geophysical Engineering Co.
San Antonio

THE CHIEF EXECUTIVE is a rare individual. Very few have the abilities required of a successful top executive. Although the middle management executive group may appear to have the same basic traits, in reality there is a wider gap than appears. Traditionally, we are used to reading and hearing of the delegation of authority and responsibility by the chief executive to subordinates. In reality this is less true than is generally realized. Although there is supposedly delegation of authority, there is no delegation of responsibility. The responsibility for major decisions rests with the chief executive. He must accept final responsibility for their outcome, whether it is a major expansion program, development of a new product or entering into other product lines.

Risk taking. From the vice-presidential level on down, risk taking diminishes proportionately. The basic function of the middle management and lower management group is to interpret and carry out policy but seldom initiate. Most decisions made by middle management are made through well defined policies of operation, deviation from which invariably must be cleared through the chief executive.

It is here that the real basic difference between chief executives and the secondary level of management emerges. Many executives who have successfully arrived, in reality have never had the responsibility for final decision. Therefore, this creates a new set of values in determining an individual's ability to lead an organization successfully. In many organizations it is assumed that the one immediately below an executive will assume the executive's job upon retirement because he has understudied his boss and therefore should be capable of assuming his duties. This fallacy of reasoning has permitted many an individual to be promoted who was capable in the job he was performing but had few of the qualities needed to perform duties of the higher job.

Exceedingly few have the qualities needed to make a successful executive, and fewer have had an opportunity to exercise the ability. So, there is and will always be a shortage of capable chief executives who have all the desirable traits required for success. For this reason it is important to continuously study and evaluate the promising man and develop him in all phases necessary for a successful executive.

Specialization. The method of promoting specialization in industry today has also tended to reduce the number who would qualify for top executive responsibilities. Executive positions in lower managerial classifications have been broken down to specific areas of responsibility. College graduates are encouraged to specialize and become experts in these particular fields. After an individual has been doing one thing for years, it becomes exceedingly hard for him to readjust his thinking to see the whole operation in balanced prospective. Almost invariably he will analyze the problem from the view of his specialized experience.

Habits. The importance of early training not only is important from over-all training but also from the development of habit traits. He who has adjusted his personality to submissiveness, and has made a compro-

The uncooperative old timer can be a real cross for the progressive executive to bear.

mised adjustment to a secondary rule, will be unable to carry out responsibility and leadership, regardless of additional training.

This is also true of the autocrat. Because he has developed an authoritarian character as a defense against his insecurities, no course in human relations will bring about a significant change or improvement in him. He may receive training in techniques of handling people but he will have trouble applying them because of their conflict with his own emotional needs.

Executive drive. Even where these deficiencies are apparent, men become presidents because of an unconscious insatiable drive which refuses to let them acknowledge their limitations even to themselves. These individuals remain successful only to the extent that the staff functioning under them is successful. However, sooner or later, unless the deficiency is corrected, deterioration occurs until there is a new president or the company becomes one of the many casualties seen every day in business.

Executive family. The management group represents a family in many respects. As in family life, the relationship between the most cordially friendly of corporate officers is at times colored by petty jealousies, rivalries and all the ordinary causes of friction between families. Again, as in family life, there is required an unquestioned fount of authority to prevent these frictions from developing into something more serious. This poses a difficult problem for the chief executive, who must assume leadership and develop the group into an efficient and cooperative working unit.

Culture residue. In many companies there are residues of the earlier organization that have been carried into the present organization, in spite of changing time and needs. That is, in an organization as well as in individual life histories, there are a good many features of behavior and habits surviving that have lost their original meaning. A situation in an organization arises calling for a certain setup. Later the need disappears, but the set-up remains. One can refer to this as a culture residue in industry, just as it could be a habit residue in the life history of a person.

Both habit residues and culture residues are found in industry fairly often. Such residues that remain, in many instances can become barriers toward the forming of a unified and coordinated organization by the chief executive.

The old-timers. The chief executive also faces another very real problem. Many executives who grew with the company may not be able or willing to assume additional responsibility, although giving lip service to the fact that it is expected. Many of these executives were able to do a satisfactory job while the organization was small and they received precise directions from the company head. The boss usually was familiar enough with all operations to make all the decisions. His subordinates saw that the decisions were followed as directed.

As the business grew, these men did not grow as they should have and found themselves unable to cope with the dynamics of a large and intricate organization. Yet, if the president brings in outside personnel capable of taking on additional responsibilities, the newcomer is inevitably thwarted by uncooperative old-timers.

Delegating decisions. Deciding who should render decisions is a deep problem of the chief executive. Duplication of functions can occur, as can friction and jealously or lack of uniformity among the various divisions in applying decisions. Yet, the chief executive cannot make all the moves. If he is required to formulate all policy and do most of the deciding, he can devote little time and thought to lesser management problems.

At the top there is less familiarity with the circumstances—so, decisions may have to be delayed until sufficient information is gathered, or data may be hastily assimilated without all necessary information. Thus, the action decided upon may be less sound and the expense greater than if re ponsibility had been delegated.

Over-centralization. Continued failure of effective decision-making because of over-centralization may lead to more centralization than before, with increasingly adverse results. This reaction may add to deterioration of an already depressed business. This collapse stems from the fact that the pressure of present day decisions leaves little time for reflection or the development of long-range plans.

AMA study. Ernest Dale of the American Management Association conducted an interior study of company organizations. He reported to the AMA Personnel Conference that he found presidents working between eight and twelve hours a day, many taking work home with them at night and over weekends. Part of his research revealed that:

- In several large companies the chief executive insisted on approving all purchases over $250.
- In many companies all salary changes above $4,000 or $5,000 must be approved by the president.
- In many companies the president personally has to approve every public appearance, however small the audience, of every member of management and whatever he may say.
- Frequently any unusual grievance must be presented to the top echelon. In some cases any grievance settlement costing money must be approved by a vice president.
- General managers of sizable divisions must go to headquarters for capital expenditures above a few hundred dollars, even if these are budgeted.
- Some company presidents have to approve all production-worker transfers and suggestion awards.
- In a number of small companies, the chief executive insisted on opening all the mail himself, and signing all replies.

The work load. Professor Sune Carlson of Stockholm University, in a report to a British Institute of Management Conference on the major research of a top management group he formed, reported his group's interest in the problem of lightening the load of top management. It analyzed the problem in detail in terms of Chester Barnard's bases of specialization.

1. **Contacts with persons and institutions**—it was found that the company presidents studied spent from 65 to 90 percent of their working time with other people.
2. **Techniques of communication**—How the president obtains and conveys information.
3. **Nature of the questions dealt**—Methods of establishing policies and precedents.
4. **Kind of action taken**—In the opinion of the presidents, most of them do not make many "final" decisions, or give orders; but their function is rather one of advisory and explaining and obtaining information.

The Swedish study found among the shortcomings of company presidents were; (1) over-exertion, (2) increased work outside the firm which creates a "vacuum in top management," (3) lack of contact with important groups inside and outside the company (4) inadequate personal inspection, (5) sidestepping the lines of authority.

The chief executive's job is unique in many respects. He truly lives in a world of his own.

A world of his own. The chief executive's job is unique in many respects. Advantages and disadvantages of the job are peculiar only to that job. As president he has more freedom from organization red tape than he had in the subordinate position leading to the top. He has a much better opportunity to initiate new ideas, new products, new lines of distribution or reducing manufacturing cost by initiating new policies. The position offers greater prestige as a reward for successful attainment, together with a larger income that comes with the position.

The most powerful of all motives, however, of most presidents is their deep-seated and urgent desire to build the kind of organization which will be known and respected as a competitor in the industry. Most experienced administrators have the same absorbing interest in building an organization for the future as a mother does in developing her children.

Loneliness a factor. There are other factors of the job which balance off the advantages. The president is basically a lonely man within an organization. He must live alone and like it. If he indulges in the luxury of thinking out loud, he sets off a chain reaction of rumors throughout the organization. He is the final focal point of all the competitive pressures of ambitious men in the organization.

If he confides in one and not in others, he immediately lowers the morale of his executive staff. If he confides in competitors they will take advantage of him. If he has outside directors on his board, they are usually too busy running their own business to have the time and interest to become intimately acquainted with his individual concerns.

The chief executive also frequently finds it a mistake to confide freely because often his own confidents have many of the same problems themselves. Thus, each succeeds only in

compounding the stresses and strains of the other.

Man or office? In addition there are many personal problems which he must face and can do little about. Among the most important is the difficulty of being built up as an office instead of as a person. Many people act toward the president in terms of preconceived ideas which they suppose will fit everyone holding the job. These people don't take into consideration the individuality of the man himself.

For example, they will throw the major burden of the conversation on the president. Often they seem to assume that the president, by virtue of his office, is an issuer of statements rather than a person who wishes to converse with other people.

Getting others to see. Another difficult problem he has is getting executives of various divisions within the company to conceive the big picture. The works manager, for example, wants to standardize on volume products to reduce manufacturing costs, while the sales manager wants to develop a variety of merchandise to please his customers.

This leads to the next problem of the chief executive. That is the inability of subordinates to get the feel of the superior's problems. It is easy for most men to be sympathetic with problems of their subordinates because they were once there themselves. In contrast, their lack of experience with problems of superiors makes a number of them almost juvenile in their expectations of top management.

Community demands. One of the last, a by-product, but as important, is the overestimating of the community or public of the chief executive's ability to support worthwhile causes. There are still many, even today, who think of the company president in terms of the millionaire entrepreneur of the bygone generation who was able and willing to give princely endowments.

There is a failure on the public's part to realize that most presidents are "high priced help," whose take-home pay is very limited after taxes in relation to the position they are supposed to maintain.

Executive responsibilities. For an organization to function smoothly and react as the chief executive desires, he has certain obligations toward his group which must be met. One of the foremost problems is competitiveness. He must reconcile the competitive ambitions of able subordinates without discouraging their initiative, by setting an example of cooperation even though it belies his own past experience of arriving to the top.

Further, he must be a model, as he sets the styles and fashions of the whole company. He holds steady under pressure. His key men learn to think ahead of the play in their relation with competitors. If he flies off the handle easily, his men will tend to be up against chronic emergencies.

Ability to listen. Another important obligation is the ability to listen. The president more than any other man in the organization must be a creative listener. He becomes the sounding board against which his key people bounce their ideas. Even though he may know in advance what the other man will say, if he is not careful even a facial expression of impatience may shut him off from the other man's confidence.

Developing subordinates. Perhaps the most intricate, subtle and intangible challenge to administrative inventiveness is the point of developing subordinates. Much of what the chief executive is able to do in the development of his subordinates depends upon his insight in sizing up the unique patter of strengths and weaknesses in individual men.

Spotting the unique personal patterns of other men, sensing their individual states of readiness for further learning and development and setting the stage wherein they can dovetail their respective efforts, all require that the chief executive be able to evaluate the unspoken attitude of others and spot the real motive behind the behavior of other men.

The degree to which the top man succeeds in getting subordinates to grow and develop also depends largely upon his own personal philosophies. The top executive can hardly spark the growth and development of the next generation of management unless he believes in men even when they have lost faith in themselves.

Executive creativity. The general change in both our society and technology is bringing about shifting pressures on the job of company president. No longer is it possible for a company to survive for any great length of time through the protection of an exclusive product, process or franchise. Research & Development departments of competitive companies breach the difference or advantage in a relatively short time.

The one remaining exclusive available to the contemporary top administrator is the building of a better organization than his competitors. The chief executive is a model. He fashions the leadership and mode of conduct. The example he sets is an outgrowth of the kind of person he is rather than the technical training he has absorbed or the business administration techniques he has learned.

The basic issues of top administration are issues of character as well as competence, and philosophy as well as science. His ability to lead and inspire determines the ultimate success of an organization. The president develops his company by developing his team and the development of the team rests upon the solid foundation of the president's continuity in developing himself and his leadership. # #

About the Author

Tver

David F. Tver is executive vice president for Petty Geophysical Co., San Antonio, Texas. He holds a B.S. and an M.S. degree in clinical and industrial psychology and has supplemented his training with courses in industrial engineering. During World War II he served as a clinical psychologist and personnel consultant with the Medical Corps. He then joined Anderson Pritchard Oil Corp., where he was made director of industrial relations. He joined Petty Geophysical in 1958.

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This Ammonia Unit EXPLODED

FIGURE 1—No. 1 counter-current tower after explosion.

FIGURE 2—No. 2 counter-current tower after explosion.

This intimate narrative takes you through a disastrous explosion at one of Japan's leading industrial plants. Kyowa Hakko Kogyo Company pulls no punches in this blow-by-blow account of a blast that claimed 11 lives

Yoshio Sakai, Light Industry Bureau
Ministry of International Trade and Industry, Tokyo

JULY 11, 1959, started just like any other day for Kyowa Hakko Kogyo Co. Ltd.'s Ube, Japan ammonia synthesis plant—up until 9:45 a.m., that is. At that moment a violent explosion ripped a gas separator at the plant. A few minutes later, a second blast destroyed an additional separator. Result: 11 deaths, 22 serious injuries, 18 minor injuries, and $694,000 worth of property damage.

Unit operation had progressed normally that fateful morning—then came a dull roar that signalled disaster. No. 1 separator's cold box exploded, shooting flames 65 feet into the air. The result was an inferno.

Cause of the holocaust, and countermeasures to prevent a reoccurrence, was determined by the Ministry of International Trade and Industry. In April 1960, the company completed construction of replacement units, built with safe, explosion-proof equipment recommended by investigators.

Situation at Explosion Time. When the primary explosion occurred, investigators found no wool insulation from the cold box in the surrounding debris. The northwest corner of the cold box was torn open 12-15 inches. Two hours later, a secondary explosion destroyed all the cold boxes' walls. This completely disintegrated all parts of the unit not ripped by the first blast, so that investigators could not reconstruct the first explosion.

Fire from the first explosion diminished five minutes after the blast, and escaping gas died down within 10 minutes. The Ube fire department arrived within 10 minutes. At this time only odds and ends of burning insulation were scattered on the unit's floor. The initial fire had ignited the asphalt-lined roof, burning the insula-

tion off electrical wiring, and setting afire the building's wooden frame.

The primary explosion was heard by the Safety Section chief in a field office 500 yards away. He immediately notified the Ube Fire Department, and all synthesis section personnel were evacuated.

The explosion occurred in the cold boxes' gas separator. (See the flow sheet of gas separator.) The box contained gas-separating apparatus for ammonia synthesis. A gaseous mixture of heavy oil, oxygen, and steam from the heavy-oil vaporizer was fed to the separator. While removing CO, CH_4, etc., from the ammonia gas (under low temperature, by liquifaction) the separator's central portion exploded suddenly—without warning.

Unit Description. The entire Synthesis Department was involved in the blast. The unit was housed in a two-story building with reinforced concrete walls. It had slate roofing over steel trusses. Built in September 1956, the unit had facilities for synthesis of ammonia by separation of mixed gas.

Pre-explosion Conditions. On May 4 the nitrogen dryer was inspected by the soap-bubble leak test. At this time, no defect was observed in the No. 2 gas separator. The next such inspection was to have taken place July 20—one week after the blast. The plant was to have been shut down at that time for close inspection.

Extinguishing Fire. Fire fighting began almost immediately after the explosion, at which time flames were confined to the cold box. Flames, which at this time were shooting 20 inches high, were attacked by the plant's fire extinguishing apparatus. This consisted of nitrogen-supply piping extending to the walls of the cold box and the unit's equipment. Also placed in use were nine fire extinguishers, two hydrants and five steam hoses. The extinguishers were used to put out a fire on the back side of the unit's instrument panel. Nitrogen compressors and blowers could not be used because of electrical failure.

The Second Explosion. At 11:45 a.m. the second explosion occurred. As in the first blast, there was no advance warning—such as the opening of safety valves. It happened suddenly—and was more violent than the first. No. 1 gas separator's cold box was blown in all directions—likewise the equipment within it. A 17-inch-thick concrete retaining wall was destroyed, and flame roared 130 feet into the air. The explosion was heard one to two miles away.

Seriously damaged in this second blast was the main safety valve for the ammonia condenser, liquid-collector valve for the ammonia cooler, and piping of the ammonia gas-liquid separator. Dense gas began to diffuse, while the fire extended to the cork-insulated piping of the No. 2 gas separator. Also set afire was insulation lining the inside of the cold box.

All personnel were evacuated after the second explosion, but many returned to rescue wounded. The scene by this time was a holocaust. Thick ammonia gas filled the air, preventing would-be rescuers from removing the dead and tending the wounded. Roll call was held to determine who was missing.

By 3 p.m. ammonia effusion had slowed. Four bodies had been removed from the scene. Flaming cork-insulated pipes were scattered throughout the gas separation building. Fire hoses were directed to the burning insulation at No. 2 gas separator. This continued on into the night, which saw the grim discovery of another body.

July 12. The next day, the company was still keeping the fire under water pressure. By 3 p.m. five more dead had been located and removed. Fire fighters began at this point to introduce nitrogen into the system to force out gas and liquid still remaining in the No. 2 separator. This continued until noon, July 13, when a gas analysis showed this approach had been successful. The water pressure was then stopped and the fire-fighting crew was dismissed. Fire inside the cold box had meanwhile been extinguished with water.

Extent of Damage. The primary explosion was minor compared with the second one. The first one partially damaged the cold box and its outer wall, eave troughs, slate roofing, window panes and electric wiring. The second blast destroyed *everything*. Dead included one company employe, three members of the Ube Fire Department, and seven members of a Ube volunteer fire squad. Seriously hurt were five company employees, seven members of the Ube Fire Department, and 10 members of the volunteer squad. Slightly injured were 18 employes and other persons.

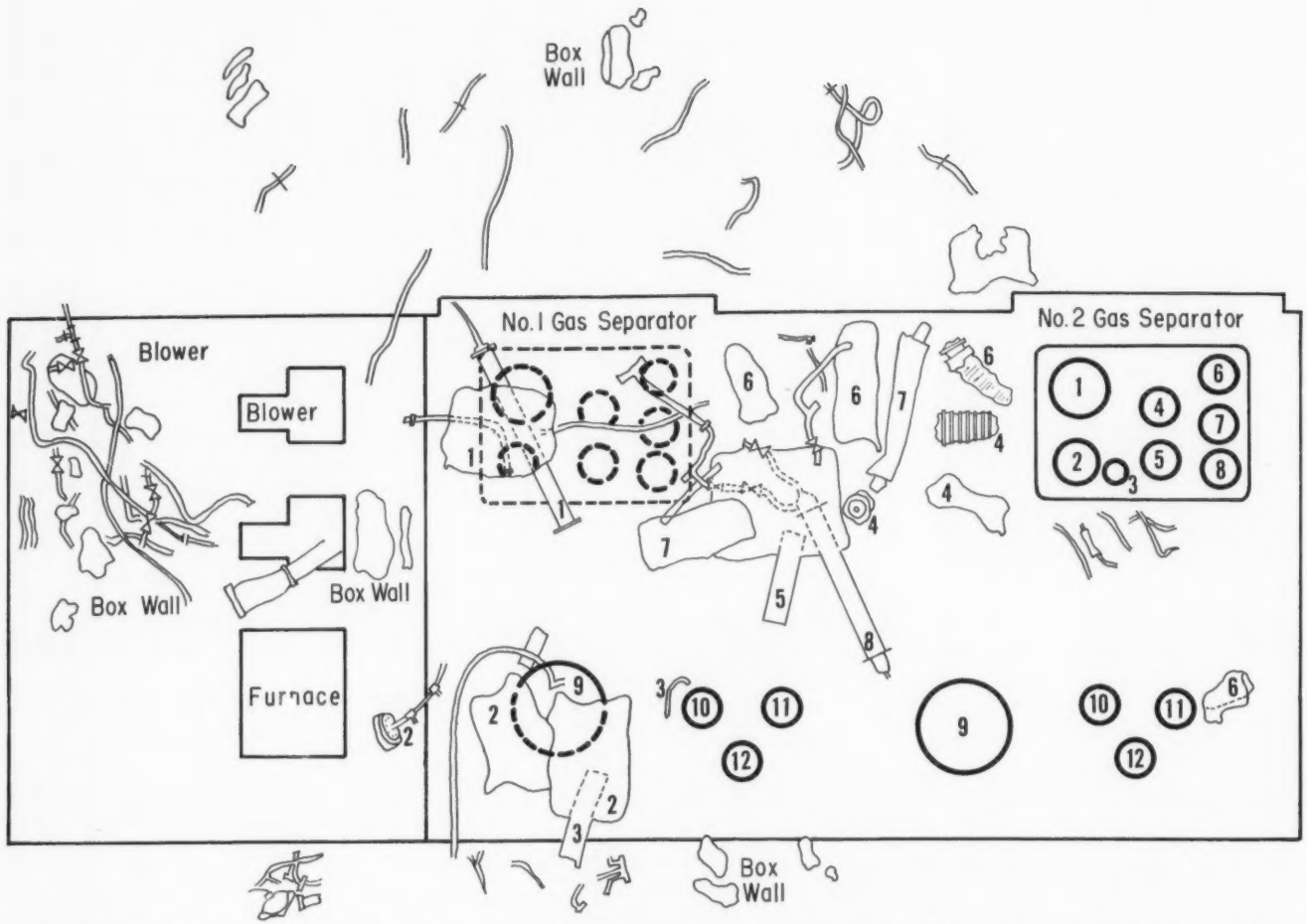
Kyowa Hakko's Ammonia Synthesis Process

Crude oil is reformed in a furnace with oxygen and steam. Output is a mixture of gases, consisting mostly of CO_2, CO and hydrogen, with some hydrogen sulfide and methane. This gas mixture is processed to eliminate free carbon—then stored in reservoirs.

The gas is treated to eliminate hydrogen sulfide in the thailox column. The treating liquid is recycled. Gas is further treated in a dry-type sulfide extractor, and conveyed into the CO converter. CO is converted, with steam, into CO_2 and hydrogen through high-temperature catalysis. The gas is again processed to eliminate sulfur before going to the reservoir.

Gas is then compressed (to 35 psi) and processed to extract CO_2 in the water washer and caustic column. Rinser water produces CO_2 as a by-product. Output gas from the caustic column is sequently processed by the gas separator, where CO and methane are completely eliminated from the gas. At the same time, the gas (hydrogen) is combined with nitrogen, in a ratio of 3:1.

Combination gas is boosted to 880 psi by a compound compressor and conveyed to the ammonia synthesis tower. There, ammonia is produced by reaction of the catalyst under high temperature (500° C). Non-reacted gas is recirculated. Product is reserved in medium-pressure and low-pressure reservoirs. Oxygen added to the process at the oil-gasifying furnace, and nitrogen used in the gas separator, are produced by another manufacturing process.



1. CO Washing Tower
2. H_2 — N_2 Heat Exchanger
3. N_2 Exhaust Exchanger
4. CO Evaporator
5. No. 3 Counter-Current Tower
6. No. 2 Counter-Current Tower
7. No. 1 Counter-Current Tower (B)
8. No. 1 Counter-Current Tower (A)
9. N_2 Pre Cooler
10-12. Counter-Current Pre Cooler

FIGURE 3—This schematic shows No. 1 gas separator after the explosion. Shock pressure from the blast was calculated at 120 atm.

Physical damage included complete destruction of No. 1 gas separator, partial destruction of No. 2 gas separator, the roof of the synthesis plant building, floor of the second story, and counter-explosion wall. Figure 3 shows No. 1 gas separator after the explosion. Shock pressure from the blast was calculated at 120 atm.

You will note from Figure 1 that the shell of No. 1 counter-current tower is partially dented, while No. 2 counter-current tower's shell is broken into two large parts, and the remainder scattered. Note that tearing exists at the welded seams and joints as well as in other places. Even some flanges (flat disc at bottom) burst outward. Tubes at the lower part were all smashed.

No. 3 counter-current tower sustained almost no damage. Part of the CO evaporator's shell was scraped off, and tube bundles were broken and torn into pieces by shock forces from the explosion. The washing tower was smashed by both shock pressure and impact, while the hydrogen-nitrogen heat exchanger sustained almost no damage. The nitrogen-hydrogen gas heat exchanger sustained minor damage at the flange. The upper and lower flange was disengaged, but almost without damage.

Cause of Explosions. The Kyowa Hakko investigating committee is still seeking the ultimate cause of the accident. Among theories the company has arrived at to date are:

(1) **No. 2 counter-current tower split internally during the gas separating process, and released crude gases from the unit which burst into flame.**

No. 2 gas separator was removed and disassembled for investigation by X-ray and ultrasonics. These tests revealed the possibility that there was a defect which weakened some of the equipment. Investigators concluded that existence of such a defect is undeniable.

(2) **An outlet pipe welded to the bottom of No. 2 counter-current separator of the gas separator came off, allowing crude gas to escape and catch fire.**

Physical inspection of all parts showed that this outlet was removed from the body. However, it is not known whether the outlet came off before or after the explosion. This could have caused the effusing gas to ignite.

(3) **Foreign articles accumulated at the bottom of No. 2 counter-current tower, inducing the explosion.** No. 2 separator was washed by caustic soda. Analysis of the caustic-soda wash water revealed almost no organic material. However, it is still very likely that there *was* organic material accumulated in the No. 1 separator.

(4) **A combination of two or more of the aforementioned theories.**

Cause of Second Explosion. The second explosion presumably originated in a low position between the carbon-monoxide evaporator and gas-washing tower. This was determined by positions of scattered pieces of the unit, with exception of the No. 2 counter-current tower. Investigation of this blast revealed:

(a) The outer tower of the carbon monoxide evaporator next to the No. 2 counter-current tower was damaged by the primary explosion's impact, and gas liquid leaked out onto the insulation, making it highly inflamable.

When fire from the original explosion reached this insulation, the secondary explosion took place. It is not yet known why the No. 2 counter-current tower blew up from the inside, or whether the cause of this blast was from the primary or secondary explosion. It is presumed that this blast was not the center of the secondary explosion.

(b) A large quantity of NO in the gas became oxidized during low-pressure gas separation, becoming NO_2. This combined with a subsidiary compound to form some highly explosive residual substance. However, company investigators found no evidence of such a substance. So, without further evidence, this has been eliminated as a possible cause.

Force of Explosion. The explosion which destroyed No. 2 counter-current tower and CO evaporator had tremendous force. Assuming that the foundation was supported on a periphery of a 120-inch radical sphere, the destroying force would amount to more than 337 psi. The explosive force that destroyed No. 2 counter-current tower's outer cylinder was calculated at more than 200 psi.

Countermeasures. The following measures were taken in construction of the new units to prevent a recurring explosion:

1. All joints and welding seams are inspected and weak joints reinforced. All outlet pipes are screwed into the body and reinforced with back welding, rather than simply jointed to the body as before.

2. All exhaust lines have service-pressure strength of 35 psi.

3. The pressure tower is constructed of stainless steel.

4. Wider spacing is allowed between boxed equipment.

5. The unit is remote controlled.

6. The new No. 2 counter-current tower is for alternate use.

7. The former inflammable wool insulation for pipes and the cold box has been replaced with non-flammable material. (slag wool).

8. Pipes and equipment are coated with non-flammable foam glass, instead of the former carbonized coke.

9. Cold boxes are separated from other general manufacturing equipment.

10. Spray and steam-type fire extinguishing facilities have been installed throughout the plant.

The company is still investigating the accident, and a conclusive report will be made public eventually.

About the Author

Sakai

Yoshio Sakai is chief of the high-pressure gas unit, Ministry of International Trade and Industry, Tokyo. He supervises the enforcement of Japan's high-pressure gas control law and its regulations. After graduation from Nagaoka Technical College in 1941, Mr. Sakai served on the Metropolitan Police Board. He joined the Ministry of International Trade and Industry in 1948.

Test Yourself on Labor Relations

No. 1. Quit Over Tough Jobs

Henry Garcia and Jim Barnes were working as a team, loading. They told the foreman they were getting too many difficult jobs. This meant that they had to work harder, and their piece-rate earnings were lower. Barnes said, "We don't mind getting tough jobs, but we don't want all of them. It isn't fair."

The men felt their work was physically punishing. Garcia hoped for lighter work because of an injured leg. Barnes had a sore wrist. Finally Garcia told the foreman: "We're going home at noon, and if you don't stop sending us ALL the tough 'skids,' we're gonna stay home. We want to be treated like the other teams."

The supervisor warned: "If you leave at noon or before your work is done, you'll be suspended for three days." At noon the two men left their jobs and returned the next morning. They were told the Superintendent had discharged them. Garcia and Barnes fought the discharge. They argued:

1. We discussed our problems and reasons for leaving the job with our foreman—and our reasons were legitimate.
2. The foreman said we would get a 3-day layoff if we left the job. He said nothing about discharge.
3. Management should keeps its word and not change the penalty without warning.

The company took another point of view:

1. The men walked off the job against the supervisor's orders. This is insubordination.
2. Garcia and Barnes' attempt to get fewer difficult "skids" interfered with management's right to assign work and direct the work force. The grievance procedure is the avenue for settling such complaints.

Test Yourself:
Was management: Right ☐ Wrong ☐

No. 2. Reporting Pay for Suspension

One morning the foreman came to check the work of Frank Coles and Hal Newsome. They were not wearing safety goggles. "Listen," he said, "You fellows know you're required to wear goggles during working hours. This is a serious violation and we may discipline you for it." With that he walked away. The next morning when Frank and Hal came to work, they were handed forms saying they were suspended for three days—starting that morning.

Both men asked for four hours reporting pay, saying, "The Agreement says we get four hours reporting pay when we report for work—if the company doesn't notify us in advance that we won't be working."

The foreman said "You guys know you don't get reporting pay if it's your own fault you're not put to work. And it's your fault you were laid off."

Test Yourself:
Was the supervisor: Right ☐ Wrong ☐

No. 3. Anti-Management Bulletin Board

One day a supervisor stopped to read the union bulletin board. He saw a letter from the union which really tore the company apart. It charged that "these managers do not want to bargain with their employes . . . and any company statement to the contrary is deliberately false." The supervisor took the letter to the Personnel Department. Personnel had copies of it removed from all bulletin boards. Later, the union committee stormed into the office. "What do you think you're doing? These are our bulletin boards."

"We have to provide you with bulletin boards," said the personnel manager, "but nothing in the Agreement says we have to take this kind of abuse. All we have to provide is a place for you to post your notices or bulletins. What's more, you have to get our approval. And I'll never approve this kind of propaganda."

"We'll see about that," said the union—and the dispute ended up in an arbitration.

Test Yourself:
Was the union: Right ☐ Wrong ☐

Answers on page 258

Best choice for throttling service...

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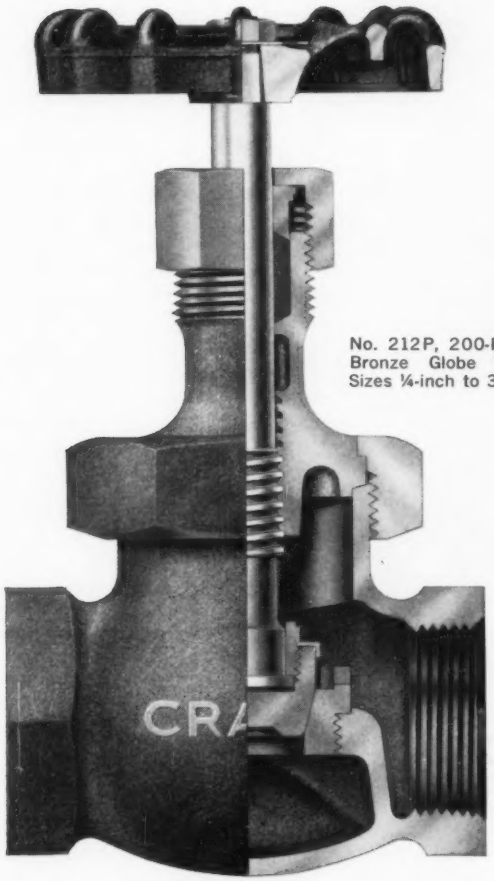

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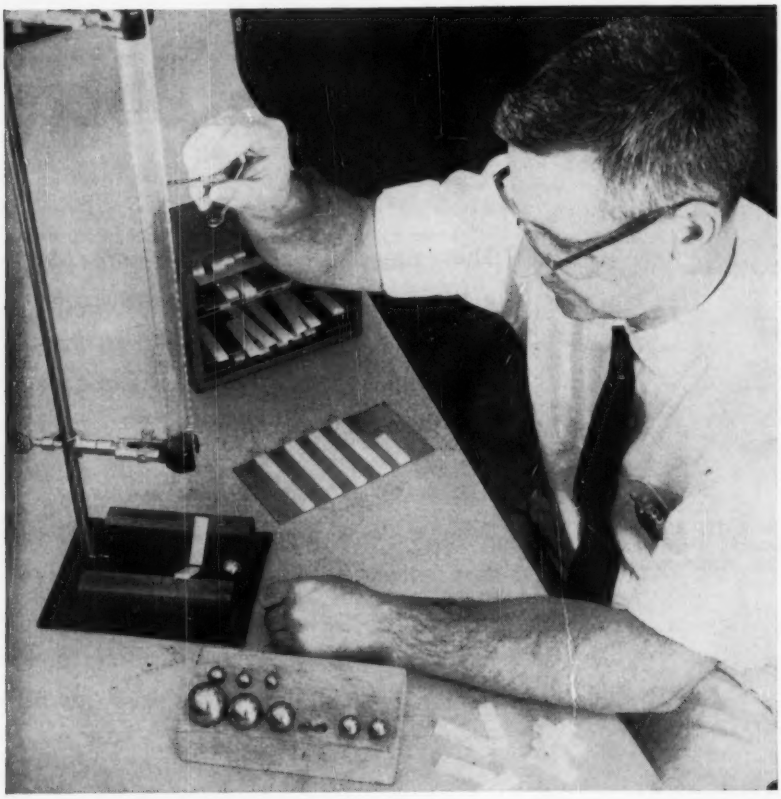


Falling steel ball checks wax brittleness.

Lab-Made Tester Finds Wax Fracture Strength

The wax brittleness tester, shown in the photo, was developed by engineers at Esso Research to solve a specific problem.

Conventional impact testers proved too strong for finding the fracture strength of waxes and were not sensitive enough for testing thin wax wafers.

Tom Camilli, Bill Gilmour and George Schael (shown adjusting the tester) suggested using a vertical plastic tube and dropping a steel ball through it, striking the wax. By drilling holes in the tube at measured intervals, the weighed ball could be dropped from various measured heights. Then, using basic physics principles—height, weight and acceleration due to gravity—the force required to fracture the wax could be accurately calculated. This simple test became a valuable tool in formulating improved coating waxes.

Item published originally in The Esso Research and Engineering *News*, Vol. 7, No. 8, and is republished by permission of *The News* and Esso Research and Engineering Co.

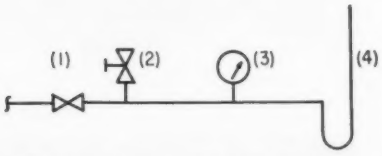
Shop-Made Device Checks Pressure Gage Accuracy

A gage can be checked by comparing the pressure it indicates with that shown on a mercury manometer connected to the same system. This gadget can do it effectively and is limited only to the range of the manometer, which is about 25 psi. It can be quickly and cheaply made up in any shop and the actual form can be adjusted as required for wall, bench or floor attachment.

Referring to the drawing, after valve (1) to which the low pressure compressed air supply is connected, there is a ¼-inch needle valve (2) used as a fine pressure adjustment by bleeding excess pressure to atmosphere. No air movement takes place beyond this valve, therefore there is no dynamic effect included in the pressures which can be recorded by the gage (3) and the mercury manometer (4).

The sequence of operation is as follows:

- Fit gage at (3).
- Check zero reading of manometer —necessary only if upward movement of the mercury is observed.
- Open needle valve (2) fully.
- Open compressed air valve (1).
- Close needle valve slowly until the gage gives the required reading.
- Read the manometer (4)—(1 inch = 0.4912 psi, 1 cm. = 0.1934 psi).



- Repeat above two steps as often as required to cover the range being tested.
- Close compressed air valve and open needle valve fully.
- Remove gage from assembly.

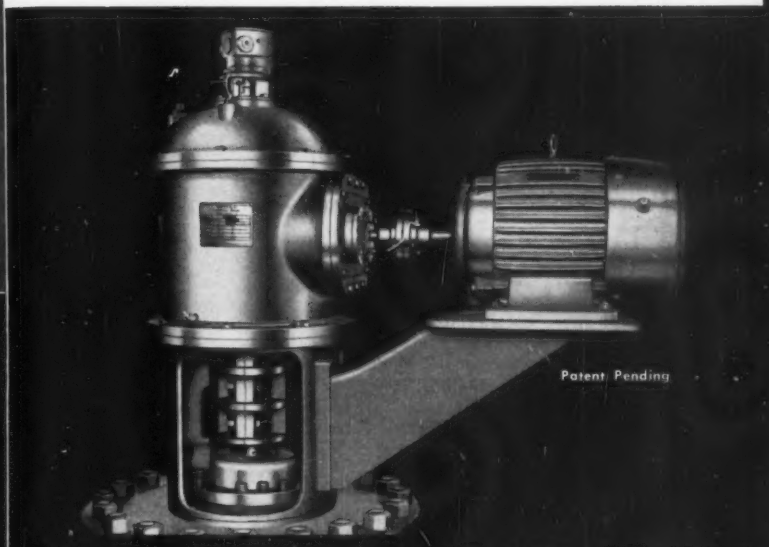
Item submitted by George E. Mapstone, Johannesburg, South Africa.

Brick Wall Isolates Compressors and Motors

Where it is necessary to recompress tower vapors, it is safer if the electric motors are isolated from the com-

CUT MIXER MAINTENANCE COST

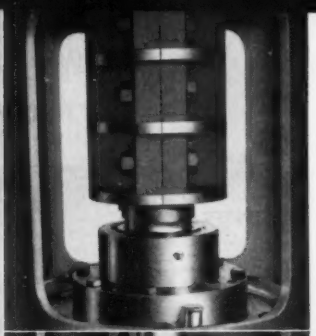
New Nettco Mechanical Seal Change Eliminates Costly Downtime



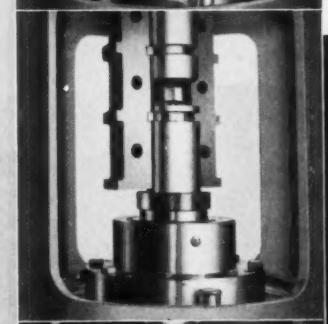
Improved Processing Through Engineered Agitation

SIMPLY DO THIS!

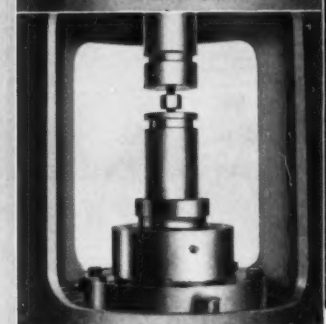
One easily assembled, self-aligning split sleeve coupling connects drive shaft and stirrer shaft.



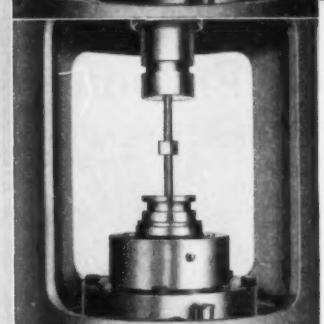
❶ Release sleeve collar set screws. Remove ½ of split sleeve coupling.



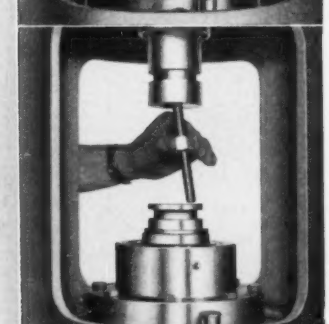
❷ Relieve shaft weight and remove remaining coupling half.



❸ Lower shaft on to support.



❹ Remove adjusting screw from opening.



❺ Unbolt and remove seal assembly. Reverse procedure to replace seal!

A few turns of a wrench . . . and Nettco seal assemblies on tank top mixers can be changed quickly, efficiently . . . regardless of mixer size. Costly downtime eliminated! Design simplicity reduces initial cost! No special skills or equipment required!

DESIGN FEATURES

- No overhead lifting device required. Result: minimum overhead space needed . . . reduced maintenance labor and less downtime.
- Compact design with minimum distance between seals and drive bearings. Result: less shaft flexing at seals . . . reduced seal wear.
- Coupling jacks eliminated. Result: no working in cramped areas.
- No dismantling mixer . . . drive bearing untouched. Result: easier, faster seal maintenance . . . no bearing readjustment problems.

Nettco's Seal Replacement is easiest ever. For complete details, write for Bulletin 601 on your company letterhead. **Nettco Corporation, 81 Tileston St., Everett 49, Mass.**

NETTCO

ENGINEERED AGITATION SPECIALISTS

EVERETT 49, MASSACHUSETTS

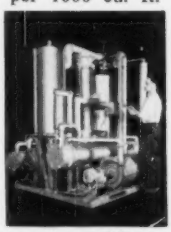
Carl G. Paulson, Director R & D group, reports

on the Hayes Nitro-Gen (TM) — low cost producer of

BLANKETING GAS

THERE ARE MANY REASONS why nitrogen's popularity is growing so fast as a blanketing gas for hydrocarbons and volatile liquids, and as a blanketing atmosphere for numerous industrial applications like food canning. Safety is a big asset of this inert, non-combustible gas. Efficiency is a deciding factor, too — nitrogen vastly improves the quality of process or product.

NEW LOW COST NITROGEN affords limitless potentials and economically, as well. With the performance-proved Nitro-Gen Generator, for example, you can produce 99.95% pure inert gas for as little as 20¢ per 1000 cu. ft. Employing Linde Molecular Sieve®*, this new Hayes generator combines stationary retort with a cyclical dryer; produces a continuous, automatic supply of gas at a very low cost; and provides a clean dry system, totally free from liquids, fumes, and corrosion problems. Best of all no highly trained specialist is required to run it.



VERSATILE, the Hayes Nitro-Gen Generator can produce gases of oxidizing and reducing characteristics, by varying the gas/air ratio. Modification of the unit permits drying large quantities of air or gas.

FIND OUT FOR YOURSELF what low-cost nitrogen, and the Hayes Nitro-Gen Generator can do for *you* . . . for food packaging, chemical processing, hydrocarbon processing or storage . . . and other applications calling for dry (dew points of –85°F or better) protective atmospheres. A Nitro-Gen unit is available for test demonstrations in our lab. Write for Interim Bulletin 5901-N1. C. I. HAYES, Inc., 853 Wellington Ave., Cranston, R.I.

*Trade Mark of UCC

C. I. HAYES, INC.

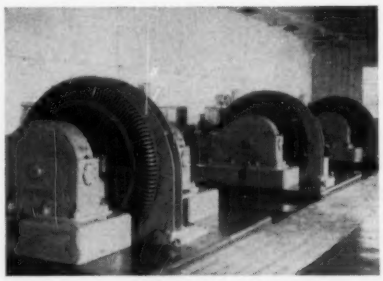
Established 1905

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, Pow-R-Trol (TM) control units.

How to Do It . . .

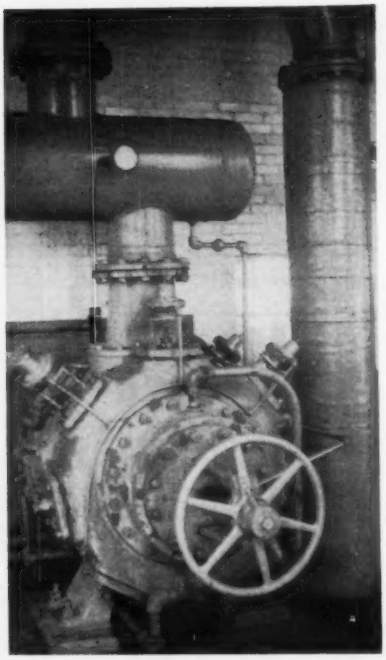
pressors in case of leaks or rupture of the compressor.

When the building is constructed, a large opening can be left where each unit is to be placed and a large



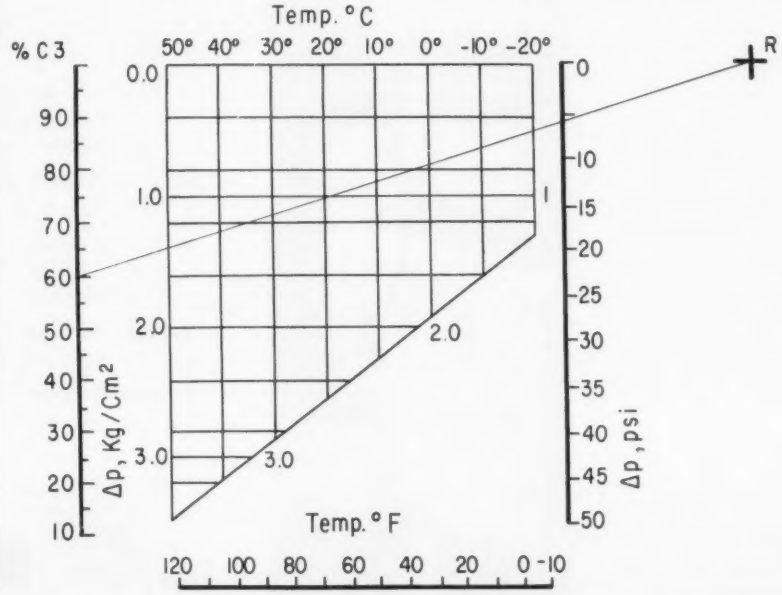
steel plate, which is removable, fills the opening. Bricks are then laid to make a wall between the electric motors and the compressors.

If one of the motors overheats or has a short, it is completely separated from the compressor room, and if a valve cap or any part of the compressor plant should spring a leak, it is completely removed from the motor room.



Find Percent C3 by Nomograph In Propylene-Propane Mixture

First, take the temperature and pressure of the mixture to be checked. From a vapor-pressure curve of pure propylene note the pressure corresponding to the temperature found for the mixture. Plot the point of intersection of p and the temperature on the nomagraph. Note, if the p



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from Steel...Oil...Chemicals

IN steel, petroleum and chemicals, profits begin with plant design. A profitable plant must be designed and built to operate efficiently now and for many years ahead—must have the built-in flexibility to meet future conditions. It must produce at rock-bottom operating cost and require minimum maintenance.

If that is the kind of plant you need call in McKee. You'll find McKee engineers get things done—done right and on time. That's the result of many years of world-wide experience on projects like yours. McKee will convert your plant *cost* into profit-earning *investment* at the earliest date—give your profit column a head start.

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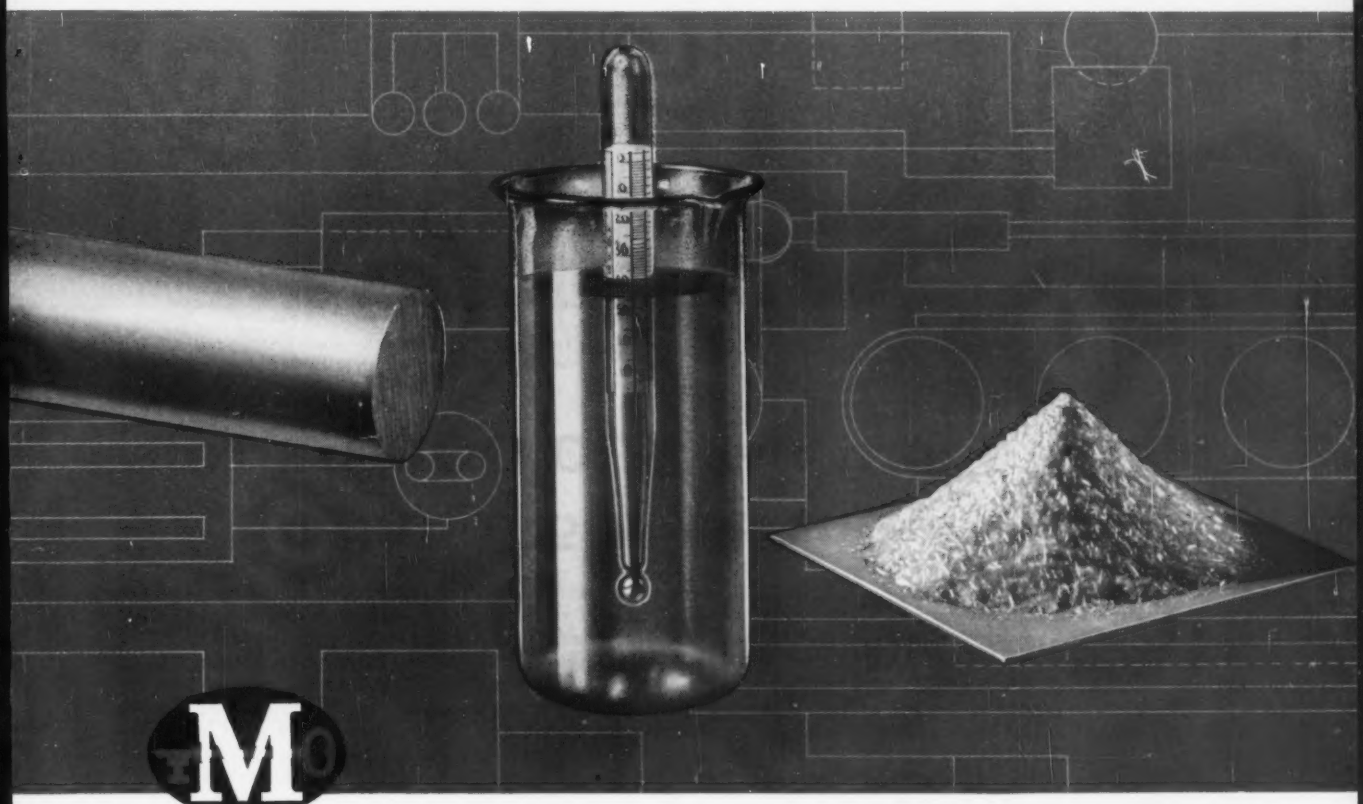
ARTHUR G. McKEE & COMPANY
2300 Chester Avenue • Cleveland 1, Ohio



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McKEE ENGINEERING AND CONSTRUCTION SERVICES

This is one of many LIGHTNIN Mixers blending fuel oils and gasoline at the Cities Service Trafalgar Refinery near Toronto, Canada.

How to turn over 90,000 barrels —without spilling a cupful

At the flip of a switch, this 25-hp LIGHTNIN Mixer starts a slow but powerful ripple of gasoline surging across the tank's bottom and up the opposite side.

Not long afterward, the entire 90,000 barrels of product in the tank are moving in a steady blending pattern. From then on, every gallon of liquid drawn from the tank will test the same as every other gallon.

The maintenance man doesn't need to worry about packing or tightening a stuffing box on this mixer. There isn't any stuffing box. Instead, a rotary mechanical seal that he never has to adjust holds the product where it belongs, without a leak.

If necessary, the seal can be replaced *in minutes*—without dismantling or removing the mixer, even under a full head of liquid in the tank.

This seal, optional on all LIGHTNIN Side Entering Mixers, is helping refiners everywhere reduce maintenance costs and shutdown time. It's only one example of the advanced thinking and up-to-date engineering you get when you choose LIGHTNIN Mixers for your big tanks.

To learn more about this cost-cutting kind of mixing, call in the LIGHTNIN Mixer man in your area. He's listed in Refinery Catalog and in the yellow pages of your telephone book. Or write directly to us.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-a Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England

known is in Kg/Cm² use the inner scale and ignore the p, psi scale. Any line connecting the reference point R and a point on the differential pressure-temperature scale (i.e. the point already plotted) intersects the percent C3 at a corresponding value.

Example: Condition of the mixture:

21° C and 10.57 Kg/Cm²

Vapor-pressure propylene:

21° C = 9.52 Kg/Cm²

Difference = 1.05 Kg/Cm²

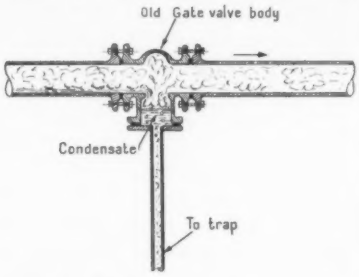
Point off 1.05 on the 21 °C line of the nomograph and draw a line from R through this point intersecting the C3 line which shows a percent C3 of 60 percent.

Idea submitted by Remy Van Haelst, Petrochim, Antwerp, Belgium.

Gate Valve Body Works As Condensate Drain

If you have a number of old gate valves to dispose of, try using the bodies as condensate drains in steam lines.

The shape of the body forms a natural pocket which insures dry



steam at the point of use.

Idea submitted by: Jose Eiroa Garcia, E.N.C.A.S.O., Madrid, Spain.

YOUR IDEAS ARE VALUABLE!

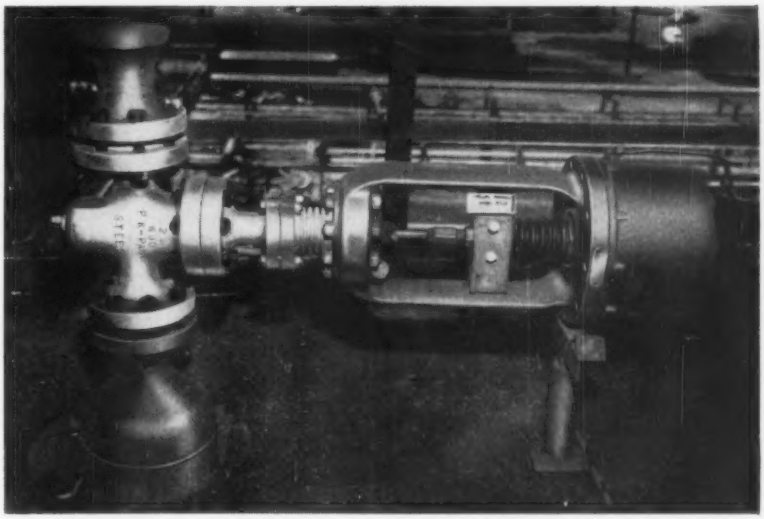
At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

CASE HISTORY
SUN OIL COMPANY

P-K PAUL VENTURI-BALL CONTROL VALVE

Solves

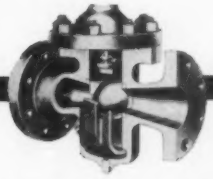
FLASHING, CORROSIVE AND EROSIVE SERVICE PROBLEM FOR THE SUN OIL COMPANY



THE P-K PAUL VALVE WAS CHOSEN FOR THIS SERVICE BECAUSE:

- The smooth Venturi passage minimizes flashing and allows a high flow capacity.
- The 2½" valve handles the high pressure drop and high velocity without difficulty.
- The simple shape of the interior of the valve body permits corrosion resistant coatings to be effectively applied.
- Overall cost savings — If an ordinary valve were used, this application would require a 4" single seated globe valve. Furthermore, the more complex interior of most globe valves complicates the problem of flashing, corrosion and erosion.

Write today for General Catalogue GV102.



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Who's Building in HPI...

Austria's First Refinery On Stream

Major part of the plant is a 32,000-bpd atmospheric distillation unit

THE NEW $22.4-MILLION, refinery of Oesterreichische Mineraloelverwaltungs A. G. (OeMV) is going on stream at Schwechat, near Vienna, Austria. It will be Austria's first major petroleum refinery.

Construction of the 32,000-bpd refinery, which consists of a distilling and a reforming unit, asphalt and an LPG plant, a power house, storage and loading facilities, began in April 1958.

To date, state company OeMV, which produces about 95 percent of Austrian crude, has been operating four company-owned refineries with a combined capacity of 28,210 bpd (60 percent of total capacity) and an 8,810-bpd plant temporarily leased from Shell-Vacuum.

OeMV's four old plants, built between 1925 and 1943, were partly destroyed during the war and rebuilt after 1945. They are eventually to be shut down or adapted to other production tasks. The company's old refinery at Schwechat, consisting of an atmospheric and a vacuum distillation unit, a lube plant and a thermal cracking unit, has been incorporated into the new refinery.

Calculations have shown that operating the new plant is financially justifiable even if one-third of the crude stock has to be imported. Savings in transportation alone will amount to $1.4 million per year; lower energy consumption will save about $1 million per year. In all, about $6 million will be saved yearly compared with OeMV's old plants. These reductions in operating costs will leave OeMV more money for prospecting work.

There will be no marketing problems for the new refinery: Within its range of 120 miles are consumed 75 percent of the gasoline in Austria, 85 percent of the fuel oil, and 80 percent of the gas oil. As consumption of petroleum products exceeds by far Austria's crude production and refining facilities, imports of products will continue and even increase in the future despite the commissioning of the new refinery. However, it is intended to add 18,000 bpd of capacity to the new refinery if domestic crude production and/or marketing conditions warrant such an expansion.

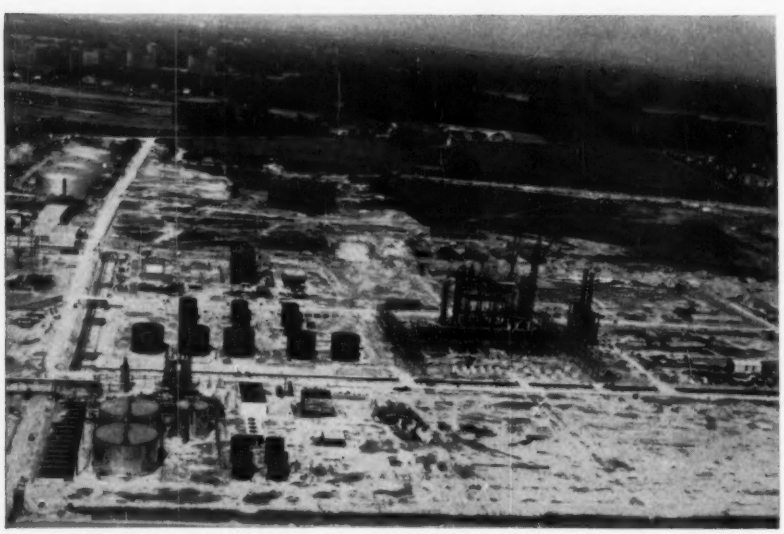
The refinery has been designed by Lurgi G.m.b.H., Frankfurt, West Germany. The reforming plant has been built under license of Universal Oil Products Co., Des Plaines, Ill.

The heart of the new Schwechat refinery is the 32,000-bpd atmospheric distillation unit. The column has an overall height of 162 feet, a diameter of 16.4 feet, a volume of 24,000 cubic feet, and a daily throughput capacity of 212,000 cubic feet.

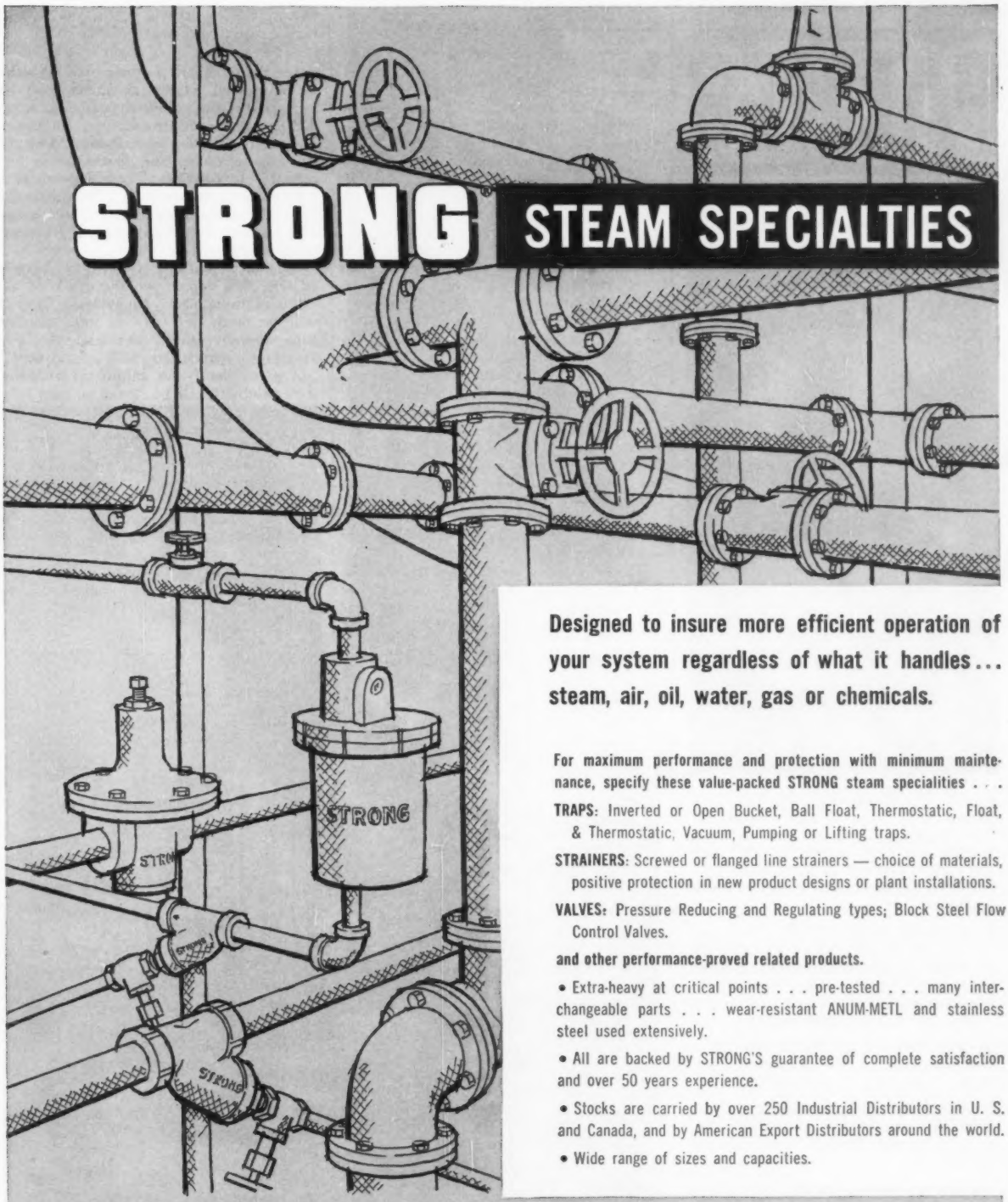
It is made of 0.702-inch steel plates with enough protection against corrosion so that besides Austrian "sweet" crude, also imported "sour" crude can be processed. The design feature of the distilling plant provides for great flexibility in operation and permits the processing of all kinds of crudes.

For the time being the charging stock will consist of Austrian asphaltic, paraffinic and mixed-base crude and of imported crudes from the Soviet Union. Austrian crude will be run to the refinery through pipelines. To facilitate the transport across the Danube River of crude from the fields to the refinery and of some of the products to the Lobau storage tanks, and 853-foot-long pipeline bridge carrying 13 lines has been built.

Soviet crude will be transported in barges on the Danube. After completion of the Soviet-Czechoslovak section of the Comecon pipelines, a continuation from



Construction site of OeMV's Schwechat refinery showing 32,000-bpd distillation unit in center, intermediate tanks to the left, and completed asphalt plant in foreground left. Danube River is seen in background.



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For maximum performance and protection with minimum maintenance, specify these value-packed STRONG steam specialities . . .

TRAPS: Inverted or Open Bucket, Ball Float, Thermostatic, Float, & Thermostatic, Vacuum, Pumping or Lifting traps.

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and other performance-proved related products.

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- All are backed by STRONG'S guarantee of complete satisfaction and over 50 years experience.
- Stocks are carried by over 250 Industrial Distributors in U. S. and Canada, and by American Export Distributors around the world.
- Wide range of sizes and capacities.

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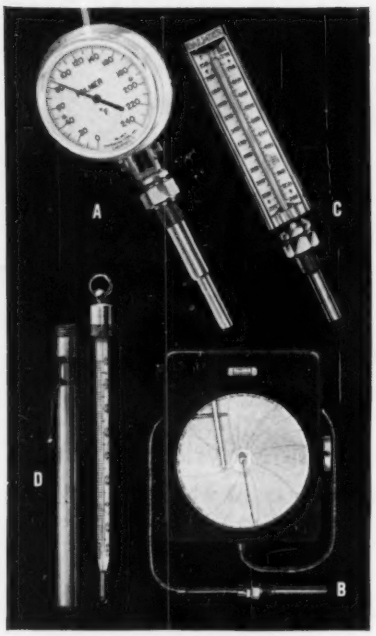

A—4½" DIAL THERMOMETERS: Made in 3 types to suit any requirements. Rigid stem, wall or flush mounted, 11 inches of scale reading. Interchangeable with standard industrial separable sockets. Stem can be placed at any angle and case can be rotated to any readable position.

B—RECORDING THERMOMETERS: Twelve inch die-cast aluminum case with black finish. Single or multiple pen construction. Electric or spring wound clock, 24 hour or 7 Day Revolution. Flexible Armor and bulb of stainless steel. Ranges: —40 +950° F or Equivalent in °C.

C—INDUSTRIAL THERMOMETERS: Red-Reading Mercury—Extruded brass case—chrome finish. Ranges: —40 +950° or Equivalent in °C.

D—RED-READING MERCURY LABORATORY THERMOMETERS: Thoroughly annealed for permanent accuracy. Complete line A.S.T.M. and fractional division types.

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Cincinnati 12, Ohio • MElrose 1 1500

Building . . .

Bratislava to Schwechat (about 30 miles) might prove feasible.

The crude charge is fractionated into white products in total, kerosine, gas oil, spindle oil, and fuel oil. After intermediate storage, the white products are split into gasoline, low boiling naphtha and heavy naphtha. Naphthenic acid is extracted from kerosine and gas oil by sodium hydroxide treatment. Gasoline, kerosine and gas oil will be pumped across the Danube to the Lobau storage tanks. Spindle oil and fuel oil will be stored in tanks on the refinery plot.

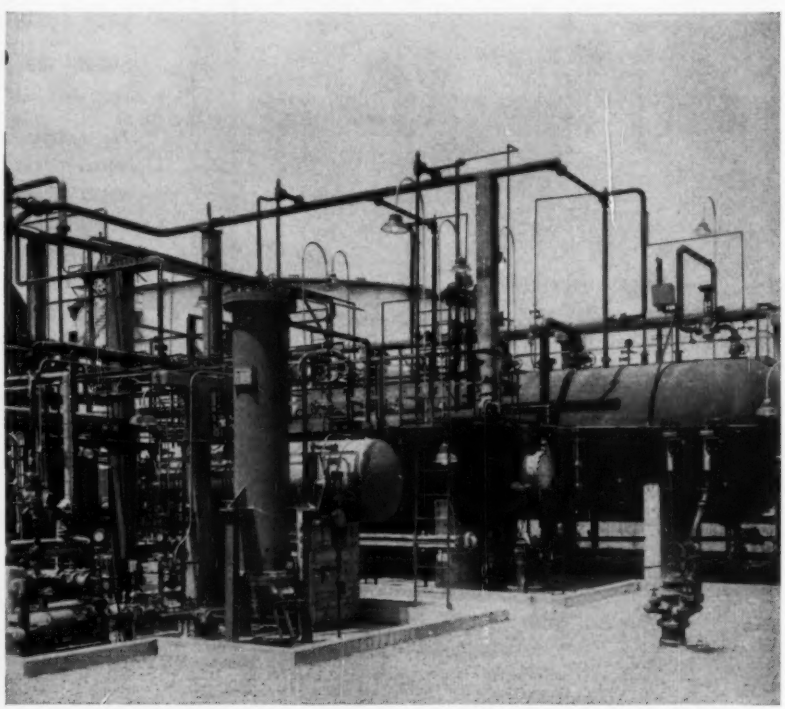
Fuel oil will be either marketed without further treatment or subjected to vacuum distillation to obtain a light fraction which, together with fractions from the atmospheric distillation, will be fed to a catalytic cracking plant that is to be built. Once the catalytic cracking plant has been added, the refinery will be able to turn out, in combination with the reformer and the thermal cracking plant of the old Schwechat refinery, 9,000 bpd of gasoline in the ratio of 4,000 bpd of regular to 5,000 bpd of premium.

Refinery gases from the distillation, reforming, and cracking units will be processed into LPG, propane, and butane. Residual gas containing chiefly gases lighter than propane will be used as plant fuel. Hydrogen sulfide will be extracted from residual gas and from LPG.

In mid-1959 the asphalt plant was put into operation as the first unit of the refinery. It consists of two vacuum distillation columns with a 1,050-1,400-bpd throughput capacity each. The charge will be naphthene-base residual fractions from Matzen crude.

The daily output, about 1,050 barrels or less, will depend on the grade of asphalt manufactured. No blowing process will be used, but only vacuum distillation, thereby giving the end products special characteristics, which lend themselves excellently for bitumen emulsions. The products will be stored in two 105,-930-cubic-foot, one 35,310-cubic-foot, and four 7,062-cubic-foot tanks.

Water for the plant is supplied from five wells. Only a small amount of the well water is used directly. The bulk, about 28,248 cubic feet per hour, is first treated. Water for cooling is first decarbonized (capacity: 28,248 cubic feet per hour), and feeding water for steam boilers is first desalted. The cooling tower that operates with fans has been designed for a capacity of 264,825 cubic feet per hour.



Merox unit sweetens 1,000 bpd of light catalytic gasoline.

Sohio Starts Up Merox Units

The Standard Oil Co. (Ohio) has announced startup of three UOP Merox units, two at Sohio's refinery at Cleveland and one at the company's Toledo, Ohio, refinery. The 12,000-bpd unit at Toledo, used for sweetening light catalytic gaso-

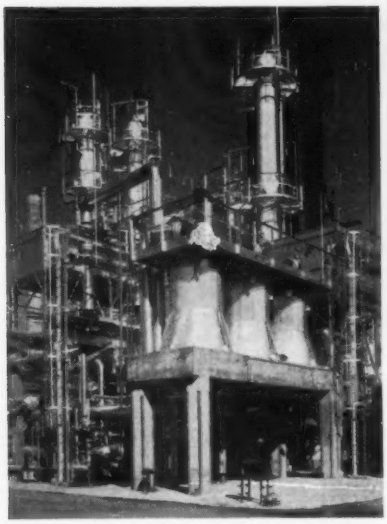
For more data on advertised products, use Readers' Service Cards, last page.

line, is one of the largest applications of the UOP treating process to be placed on stream to date.

At Sohio's No. 1 refinery here, one Merox unit is sweetening 1,000 bpd of light catalytic gasoline, while the other is extracting mercaptans from between 500 to 7,100 bpd of mixed butanes, depending on seasonal demand. The gasoline units are conversions of existing treating plants to Merox, while new equipment was installed to treat butane.

Cyclohexane Unit Finished By Continental Oil

Continental Oil Co. has completed a $1-million petrochemical plant at Ponca City, Okla., which will have an annual



capacity of more than 20 million gallons of cyclohexane.

The Conoco plant is already producing high quality cyclohexane, which is used primarily as a raw material in the manufacture of nylon.

The petrochemical plant was constructed on the company's present refinery property at Ponca City by Procon, Inc. Hydrogen from the refinery's catalytic reformers will be used to convert benzene into cyclohexane.

Borden Co. and United States Rubber Co. have selected an 850-acre site in the greater Baton Rouge, La., area for the construction of a $50-million complex of chemical plants which will convert hydrocarbons into more than a dozen chemical products. It is on this site that, as announced last May by Borden and U.S. Rubber, the jointly owned chemical company to be called Monochem, Inc., will erect a major chemical manufacturing unit using hydrocarbons as a starting point for the production of acetylene and vinyl chloride monomer. This project has been approved by the boards of direc-

HYDRANTS

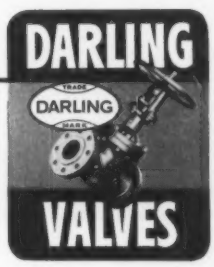
- Best for plant fire protection
- Types and sizes for all requirements

Two reasons why Darling fire hydrants can give your facilities the protection you need . . . instantly . . . *when you need it!*

First, you can locate Darlings to greatest possible advantage because there are sizes and types for every conceivable installation requirement and condition.

Second, these modern hydrants are unmatched for advanced operating features. The Darling B-50-B development means ball bearing operation combined with "O" ring seals. Result: packless, dry-top hydrants. Operating threads *stay* lubricated and water can't reach them! Operation is far easier, faster, surer . . . and maintenance is avoided.

Send for Bulletin 5710. Better still, let us send an engineer to analyze your requirements and make specific recommendations.



DARLING VALVE & MANUFACTURING CO.
Williamsport 31, Pa.
Manufactured in Canada by
The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ont.

For more data on advertised products, use Readers' Service Cards, last page.

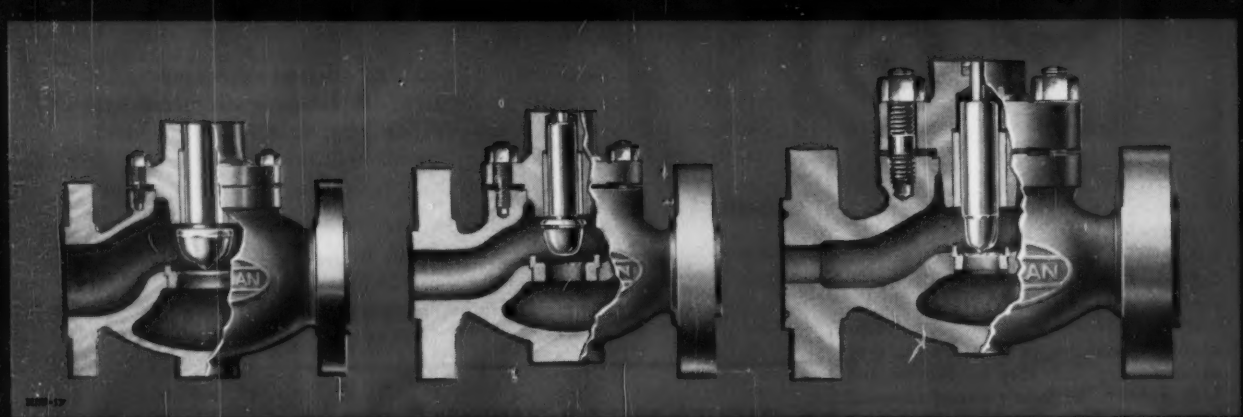
Versatility

is the word for these

SINGLE SEATED CONTROL VALVES

- **High Capacity**
- **High Allowable Pressure Drops**
- **Wide Selection of Reduced Capacity Trim**

The new line of Mason-Neilan 20000 Series Control Valves provides the most versatile single seat design available. They have an unusual combination of premium features that suit them for a wide range of applications, including viscous fluids and slurries.



Two inch, 600 lb. body with full capacity plug Two inch, 1500 lb. body with full capacity plug Two inch, 2500 lb. body with full capacity plug

High Capacity . . . top guiding, unrestricted seat ring area, body and plug contours provide greater capacity than most top-and-bottom-guided double seated valves of comparable sizes.

High Pressures and Pressure Drops . . . high capacity is attained with minimum seat ring areas, resulting in less unbalance force, permitting higher pressure drops. Heavy guiding throughout full stroke results in a minimum of unsupported plug length and allows high pressure and high pressure drop applications without lateral vibration. Generous guide surfaces and large plug stems are sized in accordance with body rating.

Soft Seat Trim . . . available in Teflon and Buna-N. Suitable for static pressures and pressure drops up to 500 psi.

Wide Selection of Reduced Capacity Trim . . . for those applications where velocity due to high drop is a consideration (or where future requirements for larger capacity are a factor) a wide selection of reduced capacity trim is available — and interchangeable in comparable valve sizes and ratings (see table). The proper relationship between stroke and trim size is maintained in order to provide the strongest possible plug tip, particularly in hard, brittle materials.

Wide Selection of Materials . . . the design of body and plug permits the use of suitable special materials to meet severe operating conditions.

Suitable for Slurries . . . body and plug contours (plus the fact that no bottom guiding is required) make these valves suitable for viscous fluids and slurries.

Welding Ends Available . . . the solid-cast body allows the use of welding ends. The removable bolted bonnet permits easy (only one joint to break) inspection or cleaning with valve in the line.

Actuators Sized to Body Rating . . . the standard spring-diaphragm (direct or reverse) actuator is sized according to body rating, thus minimizing requirements for oversize actuators in severe applications.

These 20000 Series are economical to buy and operate. Look into these many advantages; send for complete details or contact your local Mason-Neilan representative.

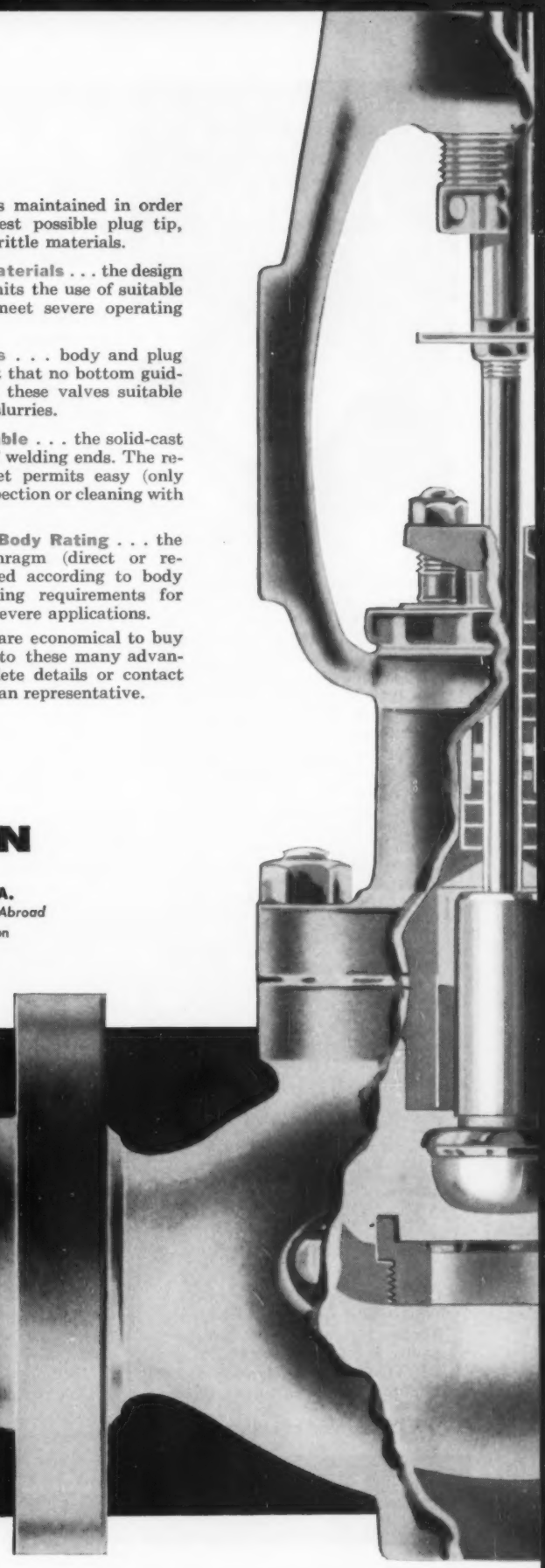
MASONEILAN

MASON-NEILAN

Division of Worthington Corporation
51 NAHATAN STREET, NORWOOD, MASS., U.S.A.
Sales Offices or Distributors in Principal Cities in United States and Abroad
In Canada: Worthington (Canada) Ltd., Mason-Neilan Division

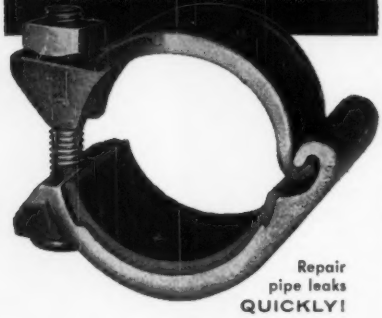
Available Cv Ratings

Valve Size	NOMINAL TRIM SIZE											
	¼"	⅜"	½"	¾"	1"	1½"	2"	3"	4"	6"	8"	10"
¾"	1.5	3.4	5.2	8								
1"	1.5	3.4	5.2	10.8	12							
1½"	1.5	3.4	5.2	12	14	25						
2"	1.5	3.4	5.2	12	18	25	46					
3"				12		25	46	110				
4"						25	46	110	195			
6"							46	110	195	400		
8"								110	195	400	640	
10"									195	400	640	1000



For Speediest Repair of Corrosion Leaks in Pipe

JUNIOR
EMERGENCY PIPE CLAMP

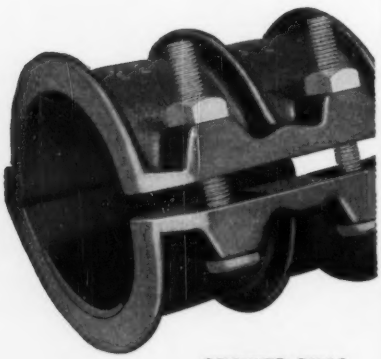


Repair pipe leaks QUICKLY!

Speediest application — slotted lug permits the single plated bolt to slide instantly into place.

A companion to the old reliable Emergency Pipe Clamp that has served industry for a half century, the JUNIOR, a single bolt clamp, is 2⅞" wide. Undersells most band-type clamps.

Made of malleable iron, ruggedly proportioned, with full-length hinge along one side. Formed to exact pipe size—no bending. The recessed pressure-equalizing gasket, entire width of clamp, is cemented in. A lasting installation. 2" pipe size—$1.80; 2½"—$2.20; 3"—$2.30. Write for new circular on the Junior.



SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12", for steel and C. I. pipe. Stocked by practically all oil supply stores.

Send for catalog!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Building . . .

tors of both companies. Borden and U.S. Rubber are to build adjacent, individually owned plants which will use the output of the Monochem plant for the manufacture of other chemical products. PETROLEUM REFINER, July 1960, Page 210.

Gulf Oil Corp.'s multi-million-dollar oxo alcohol unit is nearing completion. Badger Manufacturing Co. is in charge of engineering and construction. The new unit, one of the largest of its type ever built and the first major petrochemical unit at Gulf's Philadelphia refinery, will use heptene and nonene as raw materials for the production of octyl and decyl alcohols. The higher pressure process employed by the unit to produce the oxo alcohols is based on research carried out by Gulf over the last 10 years. The large quantities of carbon monoxide and hydrogen required by the process will be generated by separate units which have been designed by Badger.

Witco Chemical Co. has awarded Scientific Design Co., Inc., a contract for the engineering and construction of its Eastern phthalic anhydride plant. The 30-million-pound-per-year plant will use an SD phthalic anhydride process, and is scheduled for completion before the end of 1961. Witco's first phthalic anhydride plant went on stream in Chicago early this year.

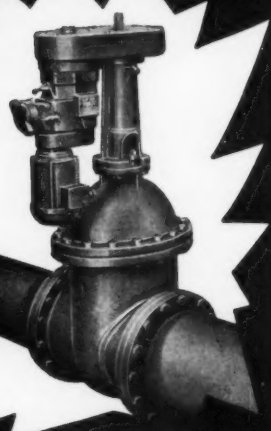
Shell Chemical Co. will build a new polypropylene plant having an initial capacity of 80 million pounds per year, using a new process developed in a four-year, multi-million-dollar research program. It is planned to locate the plant in West Deptford Township, near Woodbury, N. J.

Shell Chemical Co.'s new polyisoprene unit at its Torrance, Calif., plant is on stream with a 40-million-pound-per-year capacity. The Torrance installation is the second to be completed in the company's program of expanding its polyisoprene production to 120 million pounds per year. The company plans to build a third plant, of 80 million pounds per year capacity, near Marietta, Ohio, to reach this goal.

Monsanto Chemical Co. has completed expansion of its Research Engine Laboratory, St. Louis. This expansion doubles its previous capacity for full-scale engine evaluation of chemical additives in motor oils, gear lubricants, automatic transmission fluids and fuels.

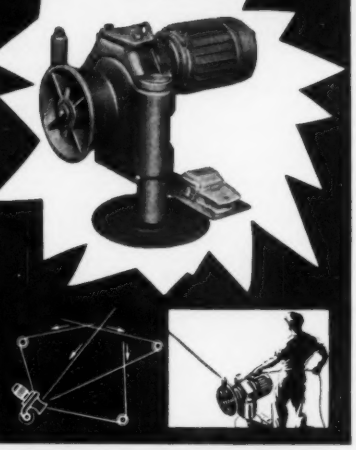
Tennessee Eastman Co. has completed the construction and equipment plans for two new plants at its Kingsport, Tenn., location. One of the plants will be for the manufacture of terephthalic acid and the other for dimethyl

SADI
VALVE OPERATORS
Adaptable to NEW and EXISTING VALVES



THOUSANDS of operators in service throughout the world, typical examples of SADI power transmission equipment quality

SADI
HAULAGE CAPSTANS
TRANSPORTABLE ECONOMICAL DEPENDABLE



SADI S.P.R.L.
4, RUE CARBURANTS
BRUSSELS 19 — BELGIUM

Building . . .

terephthalate. The projects are scheduled to be completed during the latter part of 1961.

W. R. Grace & Co. is planning a major plastics expansion program. Included is a 50-percent increase in production facilities at the Baton Rouge, La., high-density polyethylene plant and additions to the Polymer Chemicals Division's product line of a complete range of polystyrene resins as well as a full span of low and medium-density polyethylene resins.

Union Oil Co. and Goliad Co. has placed a major gas recovery system on full operation in South Louisiana. The system includes an extraction plant at Cow Island, an 86-mile pipeline, and a fractionation plant near Baton Rouge. The system will recover liquids from gas gathered both onshore and offshore. It will add about 18 million barrels of liquid products to Union's reserves. Also, Union will gain an additional 19 million barrels of liquid products as a result of processing contracts.

DX Sunray Oil Co. will begin construction on a hydrodealkylation unit at its Tulsa refinery. The unit, which will double DX Sunray's production of benzene, is the company's second petrochemical facility at the Tulsa plant. Cost of the unit will be in excess of $1 million. Completion is set for July 1961.

Continental Oil Co.'s underground cavern for propane storage is under construction at Ponca City, Okla. It will be a network of connecting tunnels about 20 feet in height and extending out from the central shaft. The 300,000-barrel cavern for propane storage is being mined in limestone at a cost of about $1,275,000. It is about 35 percent complete and is expected to be finished by April 1, 1961.

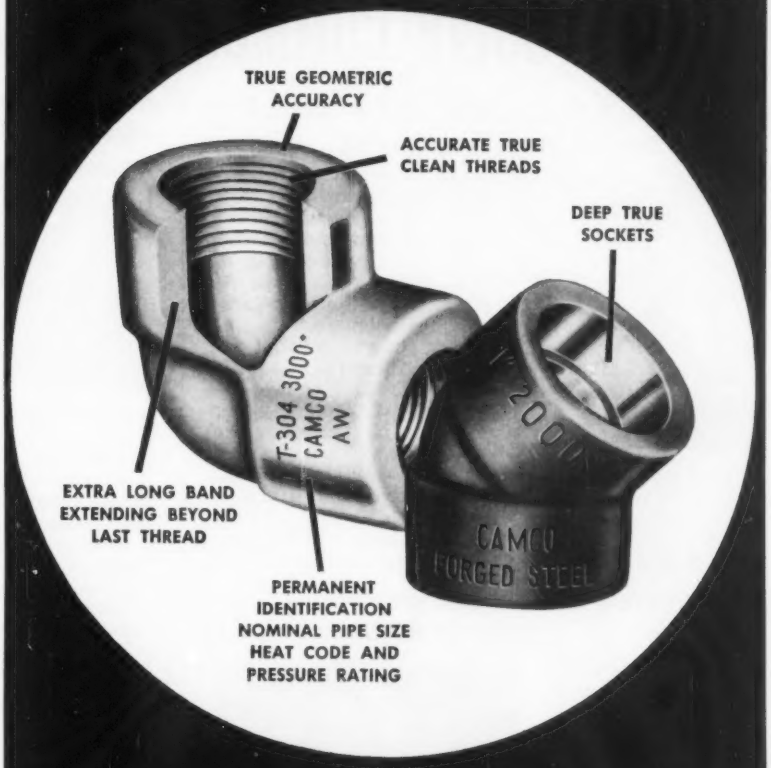
Texas-U.S. Chemical Co. has awarded a contract to Jefferson Construction Co., Port Arthur, Texas, for the construction of a new process line that will increase synthetic rubber output at its copolymer plant at Port Neches, Texas. The expansion will raise the plant's synthetic rubber production to 156,000 long tons per year.

Pacific Carbide & Alloys Co. has put a 5-million-pound-per-year vinyl acetate plant at Portland, Ore., on stream. The unit, which is adjacent to the firm's existing calcium carbide plant, will cost $500,000.

Tennessee Oil Refining Co., Houston, has awarded Badger Manufacturing Co. contracts for the engineering, procurement and construction of a 2,200-bpd Udex aromatics extraction unit and BTX separation facilities, and a 20-million-pound-per-year ethylbenzene plant. The plants will be built at the Chalmette,

CAMCO

HIGH PRESSURE DROP FORGED FITTINGS


TRUE GEOMETRIC ACCURACY
ACCURATE TRUE CLEAN THREADS
DEEP TRUE SOCKETS
EXTRA LONG BAND EXTENDING BEYOND LAST THREAD
PERMANENT IDENTIFICATION NOMINAL PIPE SIZE HEAT CODE AND PRESSURE RATING
T-304 3000# CAMCO AW
CAMCO FORGED STEEL

- STAINLESS STEEL: ASTM A-182, Grades F-304, F-316, F-304L, F-316L
- CARBON STEEL: ASTM A-105, Grade II

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Available in 2,000# thru 6,000# ratings. Screwed & Socketweld ends conforming to all applicable standards covering material and dimensional data

THE Quality LINE IN FITTINGS

CAMCO FITTINGS, INC.

SEND FOR COMPLETE CATALOG NO. 16-59

301 STATE STREET • NORTH HAVEN, CONN.

CAMCO FITTINGS

For more data on advertised products, use Readers' Service Cards, last page.

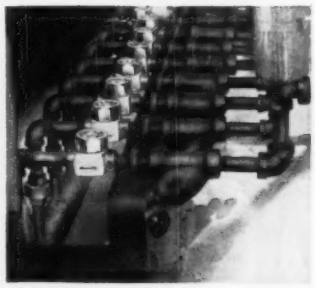
SARCO TOPICS

HOW TO SOLVE COMMON TRACER LINE PROBLEMS

How to cure water hammer with a steam trap that will operate in vertical position

Water hammer is an inherent problem in long tracer lines. So is freezing. Both problems can be overcome, and here's an example of how it has been done. At the Socony Mobil Oil Company's Paulsboro, N. J., refinery, they found that the Sarco Thermo-Dynamic Steam Trap, type TD-50, not only withstands water hammer, but installing the trap in a vertical position —which permits free drainage—presents no problems at all, thanks to its unique thermodynamic principle. In fact, 90% of the 250 TD-50's at this plant are vertically mounted. They never block heat transfer, and they remove condensate and air as fast as they collect.

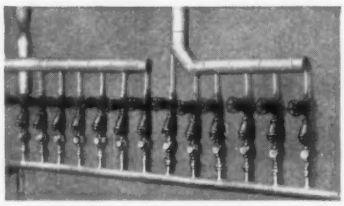
How to handle varied steam pressures — without adjustment



Can a trap — without adjustment — handle steam pressures that vary from 15 to 160 psi? Can the *same* trap vent air and drain condensate as rapidly as it is formed, be easy to install and require practically no maintenance at all? That was the problem set up by the engineering staff of Armour Chemical Division's McCook plant. They solved it by testing many traps. Their conclusion: Sarco TD-50 steam traps meet or beat their specifications, because:
they discharged condensate as fast as it formed, without wasting steam;
their compact inline construction made installation easy, even in tight quarters;
maintenance was practically negligible;
no adjustment was necessary for varying steam pressures. (In fact, the TD-50 is self-adjusting through its full operating range of 10-600 psi.)

No other steam trap can so adequately solve all these problems at one time.

How to be certain process fluid stays above 280° F. when outside temperature drops to —10° F.



The problem of maintaining design temperatures on tracer lines need not be difficult, no matter how extreme the conditions seem to be. For example, the tracer lines in a phthalic anhydride process at Witco Chemical Company's new Chicago plant had to be maintained above 280° F. Below this temperature, the chemical sets and the whole system would have to be taken apart and re-assembled. That's not all; ambient temperatures sometimes could drop to −10° F.

With reliability as a prime consideration, Scientific Design Company, Inc., who designed and constructed this brand new plant, selected the TD-50.

Because the TD-50 can be mounted vertically, freezing was no problem either. Added benefits that matter on tracer lines: the TD-50 is compact, light in weight, easy to install.

What is the most reliable tracer line trapping method to prevent unscheduled shutdown?

Particularly in refineries, steam traps have to function under exactly the kind of conditions that you'd expect to cause failure—they must function equally satisfactorily on low pressure or exhaust steam and on up through high-pressure, high temperature ranges. Not only that, but outside temperature may vary from subzero to subtropical. If maintaining design temperatures in your tracer lines appears to be hampered by these problems, consider how Phillips Petroleum Company, Kansas City, solved them. They found a trap which drains their tracer lines automatically over a full range of pressure, temperatures and loads. It's the Sarco TD-50 Steam Trap.

With only one moving part—a stainless steel disc, the TD-50 has little that can go wrong. In fact, it's so free of trouble that Phillips Petroleum Company consider their TD-50's as reliable and efficient as the piping. They now rely on 1800 of them throughout the plant. 1408

FOR FULL INFORMATION ON TRACER LINE TRAPPING or on any steam trapping problem—see your Sarco Sales Representative or write to

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

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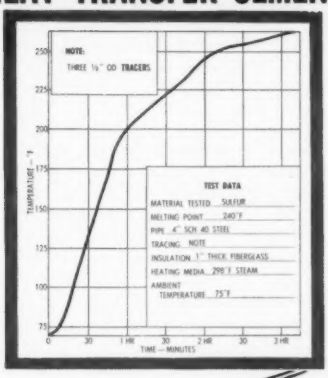
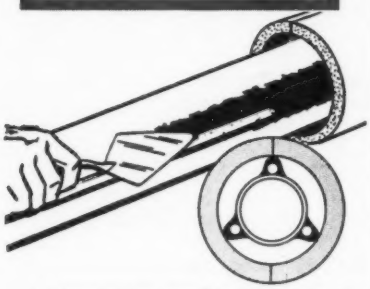
Sulphur Handling is No Problem with THERMON HEAT TRANSFER CEMENT





An increasing number of plants are using Thermon Heat Transfer Cement to eliminate sulphur handling problems encountered with internal tracing and steam jacketing. A non-metallic adhesive compound with highly efficient heat transfer properties, Thermon Heat Transfer Cement in sulphur installations

Eliminates misfitting of prefabricated pipe

Eliminates possibility of cross contamination

Eliminates need for stuffing boxes and packing glands

Reduces cost of installation by *at least one-half*

Reduces maintenance costs

Thermon has been used successfully on pumps, valves and pilot plant and other equipment in sulphur service. Investigate the problem-solving and money-saving properties of Thermon, the *proved* solution to heat transfer problems.

Write for Thermon Bulletin 300.

THERMON

THERMON MANUFACTURING CO.

1017 Rosine • P. O. Box 1961
Houston, Texas

119

Building . . .

La., refinery. Work has already started on both plants and they are expected to go on stream in mid-1961. Contracts for installation of a 6,000-bpd catalytic reformer and an orthoxylene unit, which is capable of producing 22 million pounds per year, have been let to the Bechtel Corp.

Celanese Corp. of America has agreed to buy 1,000 acres near Bay City, Texas, as a site for the construction of a petrochemical plant. Plans for building the unit are still in the formative stage.

Monsanto Chemical Co. has started building a multi-million-dollar plastics plant at Addyston, Ohio, near Cincinnati. The plant will increase the company's domestic production of heat-resistant and high-impact styrene molding and extrusion materials by 25 percent.

Enjay Chemical Co. is expanding its Baton Rouge, La., benzene plant from 15 to 25 million gallons yearly.

Solar Nitrogen Chemicals, Inc., has let a contract to Arthur G. McKee & Co., Cleveland, Ohio, for the construction of an urea plant at Joplin, Mo. Building will begin in February and the completion date is October 1, 1961. Estimated cost is between $2 and $3 million. The facility will produce anhydrous ammonia, urea and related products.

General Tire & Rubber Co. has awarded Crawford & Russell, Inc., Stamford, Conn., a contract to design and engineer a pilot plant for both continuous and batch polymerization of isoprene and butadiene to produce stereospecific synthetic rubbers. The pilot plant, when constructed, will be located at Mogadore, Ohio.

The Ohio Oil Co. has completed a natural gasoline plant with a capacity of 25,000 MMcfd at Mosherville, Mich. Humble Oil & Refining Co. holds a 35 percent interest in the unit.

Columbian Carbon Co. is building a plant for the production dispersions of carbon black in polyethylene, polypropylene and other resins. The $1-million unit will be built on a 10-acre site near the Houston Ship Channel, Houston. Walter Kidde Engineers-Southwest of Houston is the contractor.

Shell Chemical Co. is acquiring a site 15 miles west of Marietta, Ohio, on the north bank of the Ohio River, for a multi-million-dollar polyisoprene plant. The Ohio plant will have a capacity of 80 million pounds per year. Construction is scheduled to begin soon on the plant, expected to be on stream late in 1961. Plans are in progress for construction of the new plant by C. F. Braun and The

Strahman

HIGH PRESSURE GAUGES

USED IN **REFINERIES** *AND* **CHEMICAL PLANTS** *THROUGHOUT THE WORLD*

THRU VISION

REFLEX

Single or Multiple Sections

TUBULAR

Gauge Cocks

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Large Chamber Reflex Gauges

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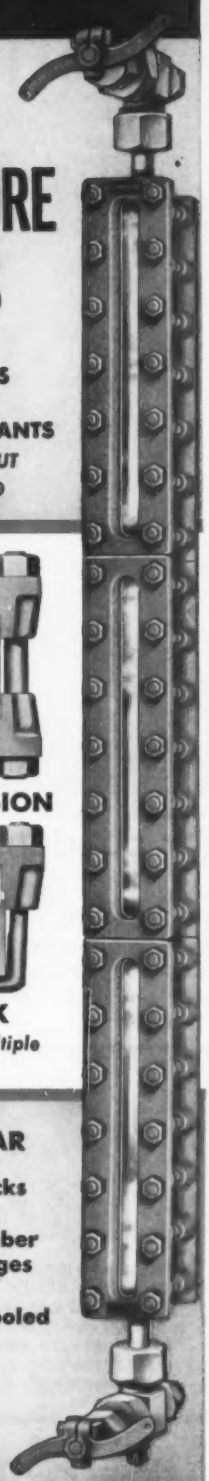
Heated or Cooled Gauges



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STRAHMAN VALVES, Inc.
NICOLET AVE., FLORHAM PARK, N. J.

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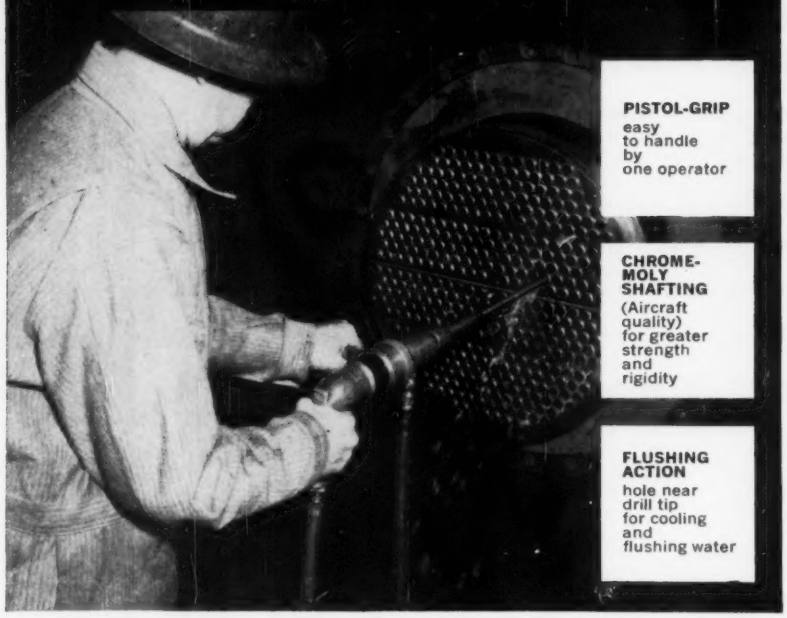
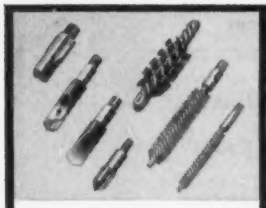
newest ELLIOTT tube cleaner

lightweight! air-driven!

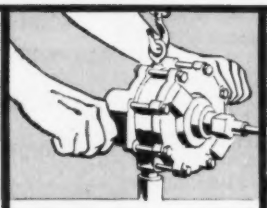

PISTOL-GRIP
easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
FLUSHING ACTION
hole near drill tip for cooling and flushing water

for condenser and heat exchanger tubes

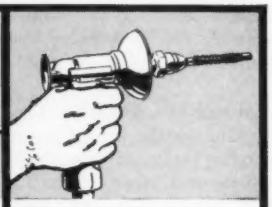
Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.



DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.



SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.



ELLIOTT JIFFY GUN
For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

ELLIOTT COMPANY
GENERAL OFFICES: JEANNETTE, PENNSYLVANIA
PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio; Newark, N. J.
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
DEAERATING HEATERS • EJECTORS • CONDENSERS • STRAINERS • TUBE CLEANERS

Y1-3

Building . . .

Ralph M. Parsons companies. Petroleum-derived feedstocks for the new installation will be obtained from Shell's Wood River, Ill., refinery.

Monsanto Chemical Co. has awarded Badger Manufacturing Co. a contract for design, engineering and construction of its phthalic anhydride plant in Gloucester County, New Jersey. PETROLEUM REFINER, October 1960, Page 212.

Amoco Chemicals Corp. will build facilities at Texas City for the manufacture of hydrocarbon resins. The plant is designed to double the present hydrocarbon resin capacity. The unit should be completed sometime this year.

Trans-Jeff Chemical Co. has placed a sulfur recovery unit in operation near Tilden, Texas. The company is a joint venture by Transcontinental Gas Pipe Line Co. and Jefferson Lake Sulphur Co.

Breaux Bridge Oil Refining Co., Inc., Houston, will place a 4,000-bpd processing plant on stream early next year near Puerto Barrios, Guatemala. Lummus Co. designed and built the plant, which was mostly prefabricated in Texas and shipped to Guatemala.

Mobay Chemical Co. plans to build additional facilities for the manufacture of tolylene diisocyanate at New Martinsville, W. Va. The expansion will boost Mobay's TDI capacity from 25 million pounds annually to 40 million pounds. Completion is slated for June 1961.

Stauffer Chemical Co. has placed a titanium trichloride plant on stream at its Anderson Chemical Division, Weston, Mich. Annual capacity of the unit is 500,000 pounds.

U.S. Phospheric Products Co. is planning an ammonia plant at Tampa, Fla., with a daily capacity of 350 tons. Completion is set for late 1961.

Dow Chemical Co. will construct a 36-million-pounds-per-year phenol plant at Kalama, Wash. The construction contract has been awarded to Hoffman Construction Co., Portland, Ore. Completion is set for mid-1962.

Enjay Chemical Co., a division of Humble Oil & Refining Co., plans to expand its Baytown, Texas, paraxylene plant. Capacity of the plant, which is operated by the Humble Division, will be increased from 65 to 105 million pounds annually by the end of the first quarter of 1962.

Shell Oil Co. will build a hydrotreater for lubricating oil at its Martinez, Calif., refinery. Construction will begin early in

For more data on advertised products, use Readers' Service Cards, last page.

AT COSDEN . . .

After five years' experience in operating Combin-aires, Cosden Petroleum Corporation, at its Big Spring refinery, has installed its FOURTH Hudson Combin-aire.

The Combin-aire is an integrated structure combining a water cooling tower with fin-tube hot fluid to air exchangers. Ambient air is cooled as it is drawn thru the water, and the cooled air serves as the cooling medium for the fin-tube coolers. Thus, with fin-tube coolers, effluent process stream temperatures may be reduced far below those obtained with ambient air.

The Combin-aire may be used primarily as a cooling tower, with the advantages of double use of air, and, because hot effluent air is undersaturated, complete elimination of spray carry over or condensation. Or when water is scarce, or salt, or brackish the Combin-aire may be used primarily for fin-tube cooling, using minimum water of any quality for pre-cooling air.

DEPENDING UPON DESIGN OBJECTIVES THE COMBIN-AIRE MAY HAVE SOME OR ALL OF THE FOLLOWING ADVANTAGES:

- Absolute minimum water consumption consistent with attainment of low terminal process stream temperatures.
- Water circulation may be made automatically responsive to air temperatures with no water circulated except at high ambient temperature.
- No water treatment necessary. Salt water or brackish water may be used.
- No spray carryover or condensation. After passing across the fin-tube elements the heated air leaving the Combin-aire at elevated temperature is undersaturated with water vapor and cannot precipitate condensate or carry water spray.
- Minimum piping. Combin-aire may be installed immediately adjacent to other process equipment.
- Clean air to fin-tube units. During the hot season air is washed, removing dust, sand and insects.

Effluent temperatures of process streams may be accurately controlled with HUDSON Auto-variable pitch fans.

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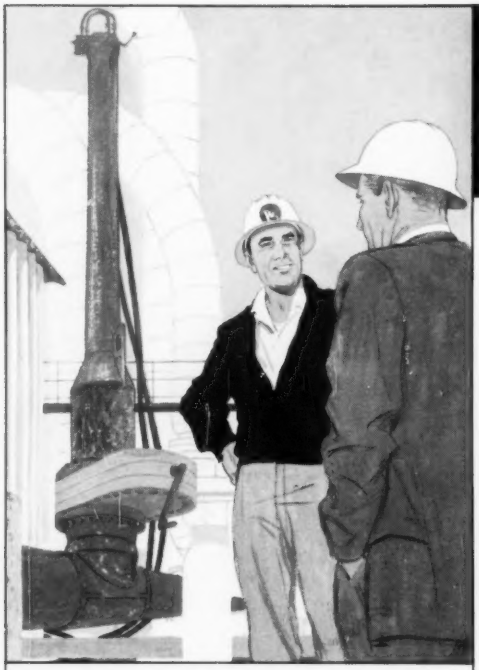
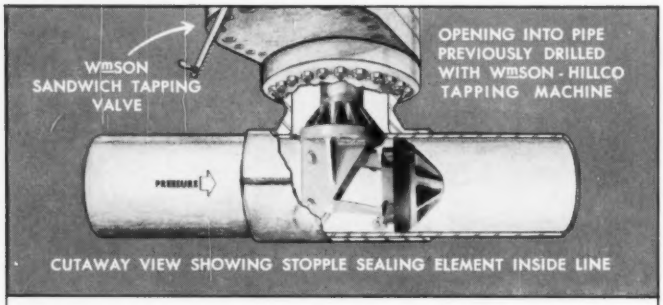


NEWS FROM DOWN THE LINE!

Another plant avoids costly shutdown with WmSON STOPPLE® Plugging Machines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OPENING INTO PIPE PREVIOUSLY DRILLED WITH WmSON-HILLCO TAPPING MACHINE
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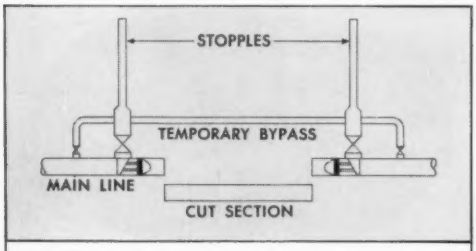
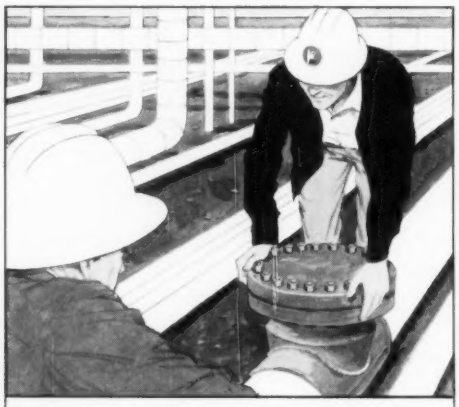
CUTAWAY VIEW SHOWING STOPPLE SEALING ELEMENT INSIDE LINE

❶ "The STOPPLE is holding pressure in this line while a gas separator is being installed. The flow is diverted through a bypass eliminating shutdown. STOPPLES serve as temporary block valves installed anywhere in a piping system."

❷ "Here's how the STOPPLE works. After the tap is made, the STOPPLE is mounted on the WmSON SANDWICH® Tapping Valve, and the sealing element is lowered into the line, stopping the flow completely."

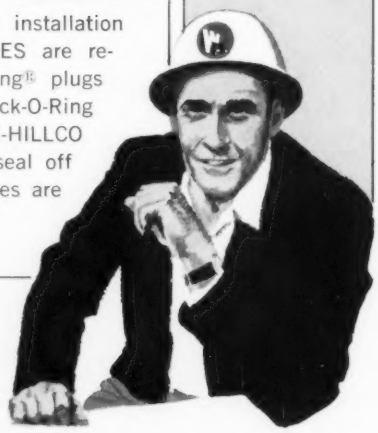


❸ "We're using a pair of STOPPLES on this job, one upstream and one downstream. Had there been an existing valve in the right place, only one STOPPLE would have been required."



❹ "When the separator installation is complete, STOPPLES are removed and Lock-O-Ring® plugs are lowered into Lock-O-Ring flanges by the WmSON-HILLCO Tapping Machine to seal off the tap. Tapping valves are recovered for re-use."

WmSON STOPPLES can be used safely in most plant and refinery applications—available for rental or purchase



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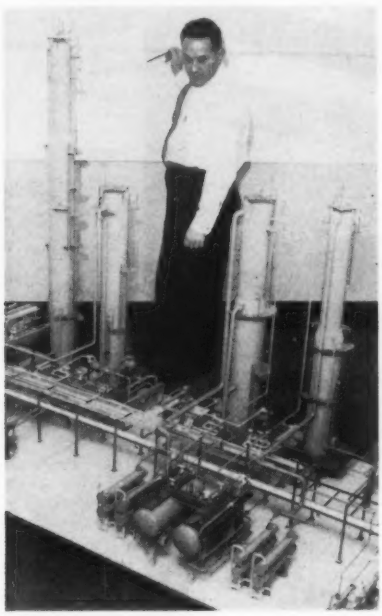
Building . . .

1961, with completion scheduled for the summer. With a capacity of 5,000 bpd, the hydrotreater removes sulfur and other impurities from low and medium-viscosity index lubricating oil stocks and transformer oils. The lubricating oil stocks are used in blending Shell's industrial lubricants and diesel engine lubricating oils.

Sun Oil to Add Gas Plant At Marcus Hook Refinery

A new gas plant will be constructed at Sun Oil Co.'s refinery, Marcus Hook, Pa. It will be tied in with a consolidation of existing gas processing facilities at a cost of approximately $9.3 million. The plant is scheduled to be in operation by November 1961.

It will have an initial capacity to separate 14,400,000 cubic feet of dry gas,



Scale model of new plant.

7,100 barrels of liquefied propane and propylene, 13,200 barrels of liquefied butane and 18,000 barrels of gasoline per day.

When the new gas plant is completed, the refinery will be able to shut down two older ones which went into operation prior to World War II.

Charge streams to the new plant will be liquids and mixed gases from various catalytic cracking plants at the refinery. Products from the gas plant will be gasoline blending stock, fuel gas, alkylation and polymerization charge, and feed to the propylene splitter.

Continental Oil Co. has completed an expansion and modernization program at its grease plant in Ponca City, Okla., costing $380,000. The project included the installation of automatic equipment for controlling temperature, flow, mixing and other steps in the manufacture and packaging of greases. The project was started about 16 months ago.

South Penn Oil Co. has placed an alkylation unit on stream at its Pennzoil Division's No. 2 refinery. The unit converts its olefinic and isobutane feed stock into approximately 1,100 bpsd of high octane motor alkylate.

Houston Chemical Corp. plans to build an 80-million-pound-per-year ethylene oxide plant at Beaumont, Texas. Scientific Design Co., Inc., will design and construct the unit.

Humble Oil & Refining Co. is weighing possibilities for the construction of petrochemical plants on a former Texas cattle ranch. Humble purchased the ranch property 22 years ago for about $8 million.

Tidewater Oil Co. and Texaco, Inc., have put their East Texas sulfur recovery unit into operation. The facility, located

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Building . . .

in Franklin County's New Hope fields, nine miles from Mount Vernon, cycles 50 MMcfd. Tidewater owns 43 percent of the plant.

Golden Bear Oil Co., Oildale, Calif., is studying plans for the addition of a 1,000-bpd catalytic hydrogen treating unit for lubes. Tenative plans are for construction to begin in 1962.

Litwin Engineering Co., Wichita, Kan., has a contract to revamp and expand the Great Plains refinery at Dickinson, S. D. Capacity will be increased from 2,500 to 4,500 bpd. Completion is set for April 1961.

Hess Trading & Transport, Inc., Sewaren, N. J., is planning to build a 30,000-bpd fluid cat cracker, 15,000-bpd Unifining unit, 40,000-bpd vacuum facility and a 2,500-bpd sulfuric alkylation unit.

Husky Hi-Power, Inc., Cody, Wyo., plans to increase capacity from 7,200 to 9,000 bpd this month. A gas-oil cracking unit and sulfuric acid alkylation unit will also be added.

NGL Corp. will build a 20,000-bpd plant south of Orange, Texas, on the Sabine River. The unit will process natural gas condensate, distillate, and natural gasoline.

Texas Gulf Producing Co. is installing a condensate fractionation unit at its Headlee plant in Ector County, Texas. Capacity will be 40 MMcfd and liquid recovery will be 80,000 gallons per day. Completion is scheduled for this month.

Pittsburgh Chemical Co. will complete facilities for 20 million pounds per year of maleic anhydride at Neville Island in the first quarter of 1961.

Dixie Chemical Co. is building chemical processing facilities in Houston. The unit now being built is a fractionation column with auxiliary equipment. The tower is designed to process about 3,000 pounds of material per hour, and will be completely instrumentated for precise automatic control, either on a continuous or batch basis.

Texaco, Inc., will build a benzene plant at Port Arthur, Texas, to produce up to 30 million gallons of benzene a year. The new plant facilities will include a Unifiner-catalytic reforming unit, a Udex extraction unit, and treating and fractionation facilities. The plant is expected to go on stream the second quarter of 1962.

Amoco Chemicals Corp. is expanding its Joliet, Ill., plant to increase dimethyl terephthalate capacity by 50 percent.

Petrobras in planning to build a synthetic rubber plant in the area of the Duque de Caxias refinery in Brazil. The unit will have a capacity of 40,000 tons per year. The facility will use raw material from the Duque de Caxias refinery, and will produce ethylene, propylene, benzene and recovery gas, in addition to synthetic rubber.

Dow Chemical Co. is building a polystyrene plant at Lavrion, Greece, a suburb of Athens. The unit is for Dow Hellenic Chemical Industry, Ltd., a Dow Chemical subsidiary.

Canadian Oil Companies, Ltd., has completed its $4-million Alberta refinery. The refinery is built on a 70-acre site with an extra 200 acres held in reserve for future expansion. It will produce 30 million gallons of gasoline per year. The plant can handle 5,000 bpd of condensate. It is also capable of processing up to 2,000 bpd of crude oil as supplementary feedstock.

Gulf Oil Corp. has announced its decision to construct an oil refinery at Stigsnaes in Southwestern Zealand, Denmark. The refinery will process 1½ million tons

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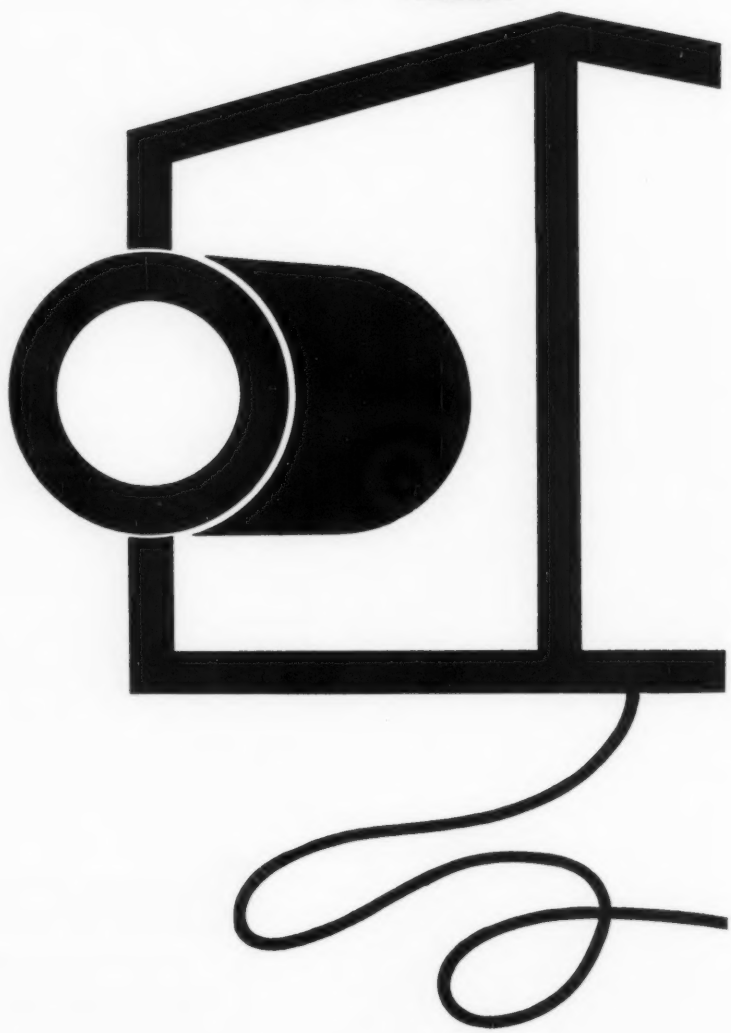

of crude oil per year of which approximately 30,000 bpd will be directed into Gulf's Scandinavian markets. It is expected that the refinery will be in full production by the end of 1962. PETROLEUM REFINER, October 1960, Page 204.

Oelwerke Julius Schindler G.m.b. H., one of British Petroleum Co.'s associate companies, is in the middle of an extensive development and modernization program at its Neuhof refinery near Hamburg, Germany. The plant's main activity is the manufacture of high-quality lubricating oils and specialties. A major part of the project is the installation of an Edeleanu dewaxing unit for the production of high-viscosity index lubricating oils. The facility will have a nominal capacity of 2,000 bpd.

Koa Oil Co. has placed Japan's first delayed coker on stream at its 7,000-bpd refinery at Marifu, Yamaguchi Prefecture. The low-pressure unit, which cost $2.2 million, will produce 60,000 tons per year of low-sulfur coke from Duri crude. The crude is furnished by Caltex in Central Sumatra. To permit runs of 10,000 bpd of 22°-gravity Duri crude, Koa has coupled the coker with a 5,500-bpd cat cracker which was completed in April.

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Thailand will build a 5,000-bpd refinery near Bangkok. Construction will be handled by Hydrocarbon Research, Inc.'s, French affiliate, Hydrocarbon Engineering, S.a.r.l. A second project under consideration is a 28,000-bpd plant.

Getty Oil Co. is considering plans to build a 40,000-bpd refinery in Bavaria, West Germany. The plant will be in conjunction with proposals for a pipeline from the Mediterranean Sea.

British Petroleum Co. is expanding its Dunkirk refinery to 52,000 bpd of mixed Middle East and Saharan crude by early next year. By adapting unused equipment, the plant is adding 11,000 bpd to its present capacity.

Finland has received $6-million credit to expand its refinery at Naantali. The Naantali plant, which is the only refinery in Finland, processes primarily Russian crude imported under a Finnish-Soviet trade agreement.

India's refining operations in Assam will be further postponed to December 1961, instead of March. The reason is delays in construction and shipments of machinery.

Kyowa Gas Kagaku Kogyo K. K., a subsidiary of Kyowa Hakko Co. and Nippon Mining Co., will build an acetylene plant at Niigata, Japan, to produce 30 tons per day. Natural gas will be the raw material and off-gas will be used to produce 110 tons per day of methanol.

Raffinerie Belge de Petroles, S. A., has placed a gas-oil desulfurization plant on stream at Antwerp, Belgium. The unit has a capacity of 6,000 bpd.

Suedpetrol A. G. fuer Erdoelwirstschaft (Ente Nazionale Idrocarburi), Munich, Germany, is looking for a site in the Stuttgart-Esslingen area of West Germany for a 40,000-bpd refinery, with capacity later to be increased to 80,000 bpd.

Iranian Oil Refining Co. has awarded a contract to Fluor Engineering & Construction Co., Ltd., London, for the construction of a 20,000-bpd UOP Unifiner-Platformer at its Abadan refinery. Design, detailed engineering and purchasing has already begun, and construction will get under way early next year. Completion is set for early in 1962.

Sweden's first petrochemical industry will be located at Stenungsund, on the west coast, north of Gothenburg. Negotiations carried on for some time have resulted in an agreement between Svenska Esso AB, which is to build a steam cracking plant, the forest industry group Mo och Domsjö, and Stockholm Superfosfat Fabriks AB, Sweden's largest

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Building . . .

electrochemical industry, which is to form a joint company with Union Carbide Corp. The total investment of the three companies is estimated at $40 million. Construction is to start early in 1961 and the plants are scheduled to go into operation in the summer of 1963. Other processing companies may later join the combine. The steam cracker plant will produce ethylene, propylene, and butadiene gases. The new subsidiary formed by the Superfosfat unit and Union Carbide will produce polyethylene plastics. The capacity will be about 15,000 tons per year at first. The Mo and Domsjö plant at Stenungsund will have an initial capacity of 10,000 tons of ethylene oxide per year.

Sun Oil Co., Ltd., is constructing a hydrodesulfurizer unit at its Sarnia, Ont., refinery. The unit, which will cost $700,000, will have a capacity of 2,600 bpd. The facility is set for completion by mid-May 1961. Sun Oil's process for hydrodesulfurization now in use at its refineries at Marcus Hook, Pa., and Toledo, Ohio, will be employed in the new unit at Sarnia.

Canadian Oil Companies, Ltd., will expand its petrochemical manufacturing facilities with a $750,000 installation at its Sarnia refinery. The new installation will double the company's benzene production to 7 million gallons annually. Construction will begin immediately on a Hydeal unit for converting toluene to benzene, a petrochemical for manufacturing plastics and synthetic rubber. It is scheduled for completion in June 1961.

Rheinpreussen A.G., Homberg, Neiderrhein, Germany, will build a maleic anhydride plant using the Scientific Design process of fixed-bed, catalytic, air oxidation of benzene. The plant, to be built at Meerbeck, will have an initial design capacity of 13,200,000 pounds per year of maleic anhydride. Scientific Design Co. will provide complete process design, process engineering, general engineering and major equipment design.

British American Oil Co. has placed its first dry dessicant type gas processing plant on stream near Gilby in Central Alberta. The largely automatic plant took little more than a month to assemble. The B-A plant, which is designed to supply a maximum of 15 MMcfd of gas at 850 psig and 80° F, has commenced delivery of sales gas to the Alberta Gas Trunk Line. Stabilized condensate recovery from capacity operation will be 210 bpd. Properly called a dry dessicant short cycle gas dehydration and hydrocarbon recovery unit, the B-A Gilby plant is basically a three-tower adsorption unit with a condensate stabilizer column and open regeneration circuit.

Tennessee Gas Transmission Co. can process crude oil right at the well with its portable "refinery" at Tierra del Fuego, in southernmost Argentina. The $70,000 mobile unit will process about 200 bpd of crude at an estimated cost of $2 per barrel.

South Western Tar Distilleries, Ltd., has placed a 7-million-pound-per-year phthalic anhydride plant on stream at Totton, England. The unit is using St. Gobain's new orthoxylene process.

Regent Refining (Canada), Ltd., is expanding the crude capacity at its Port Credit, Ont., refinery from 20,000 to 26,000 bpd. The expansion completion is scheduled for early this year. A benzene and toluene plant will be placed in operation next summer. This facility, to cost $2 million, will be engineered by Universal Oil Products Co.

Western Petrochemical Corp., has installed a bleaching unit to be used for wax production at its Chanute, Kan., refinery. The plant, which is operated by the company's Warwick Wax Division, has also placed additional vacuum distillation units on stream.

West Germany is considering plans to construct a refinery in the Frankfurt area. Farbwerke Hoechst is said to be staging plans for expansion of its petrochemical production at Frankfurt.

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Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job rating. Gulf Oil Corporation is one of many process equipment users who are benefiting from EFCO's specialized experience and engineering efficiency.

This Gulf Oil Corporation installation of Efco units, in Gulf's Port Arthur Refinery, is typical of the many high-pressure, high-temperature exchangers designed and fabricated by EFCO.

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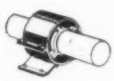

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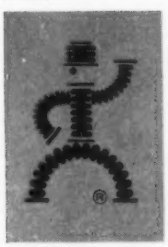

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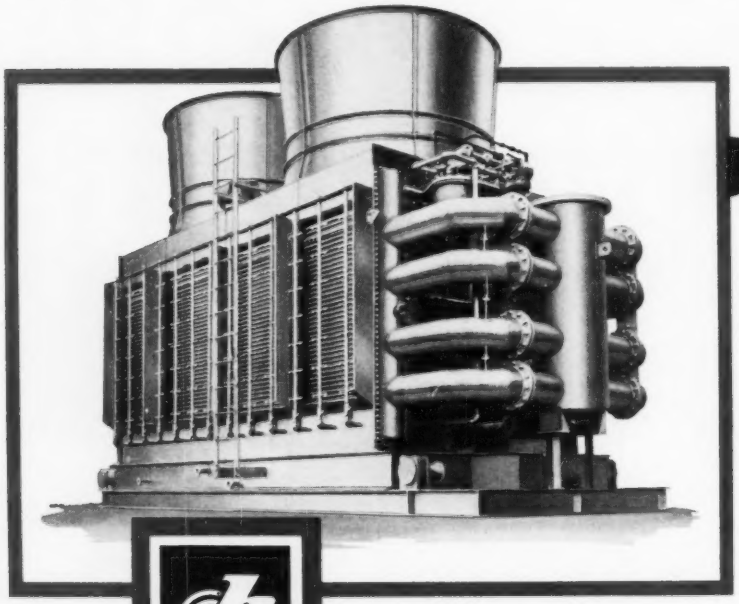
Your next question—what is an **Aquadyne?**

Here it is—the most modern concept of an evaporative vacuum condenser. If you have a cooling water problem and require a surface condenser on any vacuum system, it's an item you can't overlook, since it uses no external source of water.



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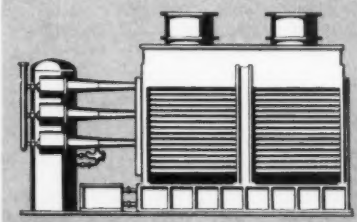


The combination you cannot beat—a Steam Vacuum Refrigeration System with the Aquadyne.

First of Year	Crude Capacity[1] (Thousand bpsd)	Alkylation Capacity (Thousand bpsd)	Alkylation Capacity (% of Crude)
1957	9,300	280	3.0
1958	9,400	308	3.3
1959	9,900	359	3.6
1960	10,000	398	4.0
1961 (Est.)	10,100	420	4.2

[1]Capacity of operating refineries reported to Bureau of Mines. Barrels per calendar day converted to stream day basis using 0.95 operating factor to account for normal shutdown involving maintenance and repair.

"Construction Boxscore" data reveal . . .

Forecast for More Alkylation Capacity

CONTINUED CONSTRUCTION of new units brings the overall installed capacity of alkylation in the United States to about 420,000 bpd. This is an increase of 22,000 bpd over alkylation capacity at the beginning of last year. From the items listed in PETROLEUM REFINER's Construction Boxscore an additional 28,000 bpd of capacity is expected to be completed during this new year.

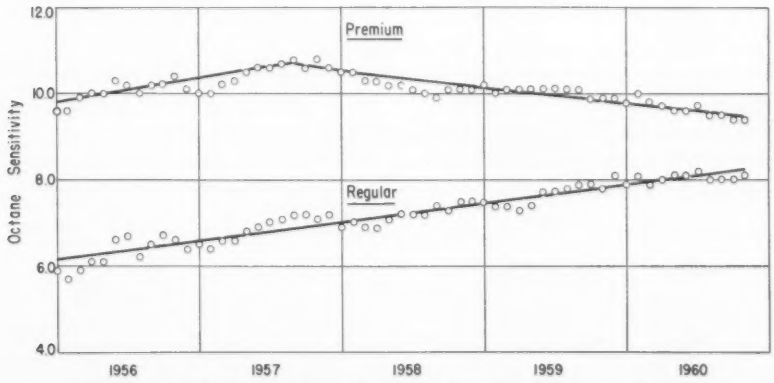
The rate of growth of new alkylation units was somewhat slower during 1960 than the preceding years. Nevertheless, the position of alkylation relative to growth in crude handling capacity continues to be strengthened, as shown in the accompanying table.

In the tabulation, the size of the refining industry for the beginning of each year is measured in terms of the crude capacity reported to the Bureau of Mines. The capacity of installed alkylation units is computed from information reported quarterly in PETROLEUM REFINER's Construction Boxscore. The alkylation capacity is figured then as a percent of the crude handling capacity—4.2 percent being the present level.

The U.S. octane picture shows one effect of the growing alkylation capacity. For the past year the average Research octane number of premium grade gasolines was steady at about 99.4. Ethyl Corp.'s Gasoline Quality Survey reports variation of only 0.1 units above and below this level for 1960. During this same period, however, the average Motor octane number continued to edge upward. Thus the difference between the higher Research octane rating and the growing Motor rating, called octane sensitivity, has narrowed.

Using data given in Ethyl Corp.'s monthly Gasoline Quality Survey, the average octane sensitivities for premium and regular grades of motor fuels marketed in the United States for the past five years are plotted in the accompanying figure. Although each monthly average sensitivity is shown, straight lines are used to show existing trends.

These trend lines show that sensitivity of premium-grade gasoline started decreasing shortly after mid-1957. The inclusion of more and more alkylate with its extremely low, or negative, sensitivity is a big factor in this decline. At the same time other gasoline blending components, such as reformate having high sensitivity as well as high overall octane level are finding their way into regular-grade gasolines—thus the rising sensitivity line for regular gasoline. Look for a continuation of these trends in the coming year as more alkylation units are installed.



Premium-grade gasolines continue recent trend to lower sensitivity.

You can review the construction of alkylation units, as well as other important construction projects, in PETROLEUM REFINER's Construction Boxscore which follows.

HPI Construction Boxscore

Hydrocarbon Processing Plants

East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Air Products	Iselin, N.J.	Liquid Helium			Under Constr				
Allied Chemical	Moundsville, W. Va.	*Exp. Chlorinated Methane				Mid 1961			
		*Isocyanate							
American Rubber & Chemical	Louisville, Ky.	Polybutadiene, Polyisoprene	30,000 tons/yr		Engineering	Sept 1961	Phillips	Staff	
		*Synthetic Rubber			Engineering		Phillips	Braun	Braun
Ashland O&R	Ashland, Ky.	Naphthalene	75,000,000 lbs/yr		Under Constr		UOP		
		Benzene	10,000,000 gal/yr		Engineering	Feb 1961	UOP	Staff	Staff
		*Cat Reformer	12,000 bbls		Under Constr	May 1961		Staff	Blaw-Knox
		*Vacuum Crude Distillation	32,000 bbls		Under Constr	May 1961		Staff	Badger Mfg
	Catlettsburg, Ky.	Benzene	15 MM gal/yr		Under Constr	Early 1961	UOP	Badger Mfg	Badger Mfg
		Catalytic Reformer	12,000 bbls	$3,000,000	Engineering	May 1961		Blaw-Knox	Blaw-Knox
		Vacuum Crude Distillation	32,000 bbls		Engineering	Early 1961		Badger Mfg	BadgerMfg
Atlantic Refining	Syracuse, N.Y.	*Asphalt Terminal	2½ MM gallons storage	$1,000,000	Under Constr	1961		Badger Mfg	Badger Mfg
Avi Sun	New Castle, Del.	Polypropylene Resin	75,000,000 lbs/yr	$30,000,000	Under Constr	June 1961	Staff	Bechtel	Bechtel
Collier Carbon & Chemical Tidewater Oil	Delaware City, Del.	*Naphthalene	100,000,000 lbs/yr		Engineering	1961	Union Oil-Cal		Catalytic
Du Pont	Belle, W. Va.	Methyl Methacrylate			Planning	1961			
	Memphis	Acrylonitrile			Under Constr	1961			
Florida Oil & Refining	Jacksonville, Fla.	*Refinery	15,000 bbls		Planning				
Foster Grant	Leominster, Mass.	Plastic Polymers, Copolymers, Styrene Monomer, Molded Plastics		$4,000,000	Planning				
Goodyear	Niagara Falls, N.Y.	Exp. Polyvinyl Choride			Under Constr	July 1961			
Grace Chemical Div., W.R. Grace	Memphis	Exp. Ammonia	450 tons		Under Constr	Mid 1961	Chemico	Chemico	Chemico
Gulf Oil	Philadelphia	Oxo Alcohols	35,000,000 lbs/yr		Under Constr	1961	Gulf Oil	Badger Mfg/Gulf	Badger Mfg/Gulf
Hatco Chemical	Fonds, N.J.	Phthalic Anhydride	22,000,000 lbs/yr	$2,500,000	Under Constr		Sherwin-Williams	Badger Mfg	Badger Mfg
Hercules Powder	Burlington, N.J.	Dimethyl Terphthalate	36,000,000 lbs/yr		Complete				
Hess Trading & Transport	Sewaren, N.J.	Exp. Refinery	35,000 bbls		Planning				
		Udex			Planning				
		Catalytic Cracking			Planning				
Heyden Newport Chemical	Fords, N.J.	Maleic Anhydride	24,000,000 lbs/yr		Under Constr	Early 1961		S D	S D
Koppers	Follansbee, W. Va.	Desulfurization	60,000,000 lbs/yr		Complete			Ehrhart	Staff
Monsanto Chemical	Logan Township, N.J.	*Phthalic Anhydride			Engineering	1961	Sherwin-Williams	Badger Mfg	Badger Mfg
Novamont	Neal, W. Va.	Isotactic Polypropylene, Other Petrochemicals	22,000,000 lbs/yr		Under Constr	Early 1961	Monte-catini	Staff	Staff
Olin Mathieson	Brandenburg, Ky.	Ethylene Oxide			Under Constr		Shell Devel	Lummus	Lummus
	Saltville, Va.	*Hydrazine		$14,000,000	Under Constr	1961		McKee	McKee
Pittsburgh Coke & Chemical	Neville Island, Pa.	Maleic Anhydride	20,000,000 lbs/yr		Planning	Early 1961		SD	SD
Reichhold Chemicals	Tuscaloosa, Ala.	Formaldehyde	35,000,000 lbs/yr		Planning		Staff	Staff	Staff
		Phenol		$2,500,000	Under Constr				
Shell Chemical	Woodbury, N.J.	*Polypropylene			Engineering	1962	Shell	Braun	Braun
Shell Oil	Little Creek, Miss.	Natural Gas Liquids	5 MMcf		Planning				
Stauffer Chemical	Delaware City, Del.	Carbon Bisulfide			Under Constr	1961		Staff	
Sun Oil	McComb, Miss.	Natural Gasoline	20 MMcf	$1,400,000	Complete			Pona	Pona
	Marcus Hook, Pa.	*Automatic Tank Gauging		$428,000	Under Constr	Spring 1961		Staff	Staff
		*Product Control		$150 000	Complete			Staff	Staff
		*Crude Blending		$230,000	Under Constr	Spring 1961		Staff	Staff
SunOlin Chemical	Claymont, Del.	Ethylene	685,000 lbs	$17,000 000	Under Constr	Jan 1962		Lummus	Lummus
		Ethylene Oxide	164,000 lbs	$3,000,000	Under Constr	Jan 1962	Shell	Lummus	Lummus
		*Carbon Monoxide	1,000,000 scf	$2,500,000	Engineering	Jan 1962		Air Products/ Kellogg	Air Products/ Kellogg
		*Hydrogen	12,000,000 scf						
Tennessee Corp.	East Tampa, Fla.	Ammonia	100,000 tons/yr	$13,000,000	Planning	Early 1962			
U.S. Steel	Clairton, Pa.	*Tar Distillation			Under Constr	1961		McKee	McKee
United Refining	Warren, Pa.	H_2SO_4 Alkylation	1,100 bbls	$1,300,000	Complete			Kellogg	Kellogg
U. S. Phosphoric Products	East Tampa, Fla.	*Ammonia	300 tons		Engineering	Late 1961	Chemico	Chemico	Chemico

Mid-Continent

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	South Point, Ohio	Exp. Methanol	50%						
		Exp. Formaldehyde	35%						
Amoco Chemicals	Joliet, Ill.	*Aromatic Acids & Esters		$1,000,000	Under Constr	1961		Tears	Staff
Antelop Gas Products	Kimball, Neb.	Natural Gasoline	10 MMcf		Complete			Olsen	Olsen
Borden Chemical	Illiopolis, Ill.	Polyvinyl Chloride	40,001,000 lbs/yr	$4,000,000	Planning				
California Chemical	Ft. Madison, Iowa	*Ammonia	300 tons	$22,000,000	Engineering	Late 1961		Staff	Bechtel
		*Nitric Acid	250 tons						
		*Ammonium Nitrate	150 tons						
		*Complex Fertilizer	600 tons						

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Century Refining	Garden City, Kan.	*Cat Cracking	3,000 bbls		Complete		Socony	Litwin	Litwin
		*Gas Concentration						Litwin	Litwin
Champlin Oil & Refining	Enid, Okla.	Exp. Cat Cracker	20,000 bbls		Under Constr		Kellogg	Staff/Kellogg	Staff
		Exp. Alkylation	2,000 bbls		Under Constr		Kellogg	Staff/Kellogg	Staff
		Delayed Coker	4,000 bbls		Under Constr	Sept 1961		Staff/Fluor	Staff/Fluor
Continental Oil	Ponca City,	Cyclohexane	20,000,000 gal/yr	$1,000,000	Under Constr				Procon
Cooperative Farm Chemicals	Lawrence, Kan.	Ammonia	100 tons		Under Constr			Chemico	Chemico
		Urea	30 tons	$5,400,000					
Dow Chemical	Midland, Mich.	Exp. Styrene Monomer			Under Constr				
		Phenol Distillation		$650,000	Under Constr			Badger Mfg	Badger Mfg
DX Sunray	Tulsa, Okla.	Propane Deasphalting	6,000 bbls	$1,000,000	Complete			Foster Wheeler	Foster Wheeler
		Crude Distillation	85,000 bbls	$6,500,000	Under Constr	Sept 1961		Foster Wheeler	Foster Wheeler
		*Toluene	1,000 bbls		Under Constr	Mid 1961		Foster Wheeler	Foster Wheeler
		*Hydeal		$1,100,000	Engineering	Summer 1961	UOP	UOP	Foster Wheeler
Goodyear Tire & Rubber	Akron, Ohio	*Exp. Nitrile & Latex			Engineering	1961			
Gulf Oil	Toledo, Ohio	Crude and FCCU Revamp			Under Constr		Gulf/ Kellogg		Kaighin-Hughes/ Kellogg
Koppers	Cleveland, Ohio	*Sulphur Recovery	6 tons		Under Constr	1961	Pan American	Tears	Tears
Monsanto Chemical	Monsanto, Ill.	Exp. Phenol			Under Constr	Mid 1961			
	El Dorado, Ark.	Urea Distillation			Under Constr			Chemico	Chemico
	St. Louis	Exp. Maleic Anhydride	20,000,000 lbs/yr		Under Constr			SD	SD
National Cooperative Refinery	McPherson, Kan.	Delayed Coker Revamp		$1,200,000	Engineering	Fall 1961		Staff/UOP	Procon
Phillips Chemical	E. St. Louis, Ill.	*Ammonia Storage	15,000 tons		Under Constr	1961		Girdler	Girdler
RJ Oil & Refining	Princeton, Ind.	Unifiner	1,700 bbls		Planning				
		Crude Distillation	5,000 bbls		Under Constr				
		Platformer	1,700 bbls		Planning				
Shell Chemical	Marietta, Ohio	*Synthetic Rubber			Engineering		Shell	Braun	Braun
Shell Oil	Wood River, Ill.	Catalytic Reformer & Offsite Facilities	25,000 bbls	$15,000,000	Under Constr			McKee/Parsons	McKee/Parsons
	Healdton, Okla.	Exp. Plant		$315,000	Under Constr			Staff	Hudson
Skelly Oil	Minneola, Kansas	Gasoline	25 MMcf		Engineering	March 1961		Dresser	Dresser
Solar Nitrogen	Joplin, Mo.	Ammonia	300 tons		Under Constr	April 1961		Kellogg	Kellogg
		*Urea	150 tons		Engineering	Oct 1961	Stami-carbon	McKee/Stami-carbon	McKee
Standard-Indiana	Whiting, Ind.	Alkylation	11,400 bbls		Engineering	1961		Bechtel	Bechtel
		CO Boiler			Under Constr	1961		Babcock & Wilcox	Staff
	Wood River, Ill.	Polybutene			Under Constr			Procon	Procon
	Neodesha, Kan.	Exp. Crude	7,500 bbls		Under Constr			Staff	Staff
Standard-Ohio	Lima, Ohio	CO Boiler		$1,500,000	Complete		Babcock & Wilcox		
	Toledo, Ohio	*Isocracker	7,500 bbls	$4,000,000	Engineering	Late 1961	Cal Research	Cal Research	Parsons
Sun Oil	Toledo	Propane Deasphalting	9,500 bbls	$3,600,000	Under Constr	Spring 1961		Staff/Foster Wheeler	Foster Wheeler
		Naphthalene	100,000,000 lbs/yr	$8,000,000	Engineering	Late 1961		Staff	Kellogg
Sunray Mid-Continent	Purcell, Okla.	Exp. Natural Gasoline	25 MMcf	$600,000	Complete			Staff/Tuloma	
Union Carbide	Marietta, Ohio	Bisphenol-A	25,000,000 lbs/yr		Under Constr	Early 1961			
	Whiting, Ind.	Low-density Polyethylene	72,000,000 lbs/yr		Under Constr				
Warren Petroleum	Mocane, Okla.	Exp. Gasoline	to 200 MMcf		Engineering	March 1961		Dresser	Dresser
Western Petrochemicals	Chanute, Kan.	Vacuum Distillation	500 bbls		Complete			Litwin	Litwin
		Propane Deasphalting	350 bbls		Complete			Litwin	Litwin
		*Wax Decolorizing	300 bbls		Complete		Socony	Litwin	Litwin

Southwest

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	Orange, Texas	Polyethylene Glycol			Under Constr				
	Baton Rouge, La.	*Polyethers	20,000,000 lbs/yr			June 1961			
Aluminum Co. of America	Point Comfort, Texas	Exp. Natural Gasoline	150 MMcf		Under Constr	Feb 1961		Olsen	Olsen
American Oil	Texas City	Crude	150,000 bbls		Under Constr	Fall 1961		Kellogg	Kellogg
		Cat Cracker	47,600 bbls		Under Constr	Fall 1961		Kellogg	Kellogg
		Alkylation	14,600 bbls		Engineering	Fall 1961		Fluor	Fluor
		Butane splitting, Isomerization							
Carbide & Carbon	Seadrift, Texas	Exp. Ethylene Oxide	to 200,000,000 lbs/yr		Planning			B & R	
		Exp. Polyethylene			Engineering			B & R	
	Texas City	Exp. Ethylene Glycol	65 MMcf		Planning				
Carwin	Houston	Special Isocyanates	1,5000,000 lbs/yr	$1,000,000	Under Constr	1961		Pona	Mundy Constr
Celanese	Houston	*Polyolefins			Under Constr	Early 1961	Phillips	Braun	B & R
Cities Service	Lake Charles, La.	Udex Extraction, Orthoxylene Recovery	120,000,000 lbs/yr	$4,500,000	Under Constr	May 1961	UOP	Badger Mfg	Badger Mfg
Coastal Products	Corpus Christi, Texas	Delayed Coking	7,000 bbls	$3,000,000	Under Constr			Treco	Treco
Continental Oil	Lake Charles La.	Straight-Chain Primary Alcohols	50,000,000 lbs/yr		Under Constr	Early 1961			
		Exp. Natural Gasoline	to 150 MMcf		Under Constr	Jan 1961		Hudson	Hudson
Copolymer Rubber & Chemical	Baton Rouge, La.	Rubber	to 118,000,000 lbs/yr	$3,000,000	Under Constr	Jan 1961		Staff	Staff
		Butadiene	to 55,000 tons/yr	$5,000,000	Under Constr	Sept 1961	Dow	Foster Wheeler	Foster Wheeler
Cosden Petroleum	Big Spring, Texas	Exp. Styrene	to 70,000,000 lbs/yr		Under Constr		Staff /UOP	Badger Mfg	Badger Mfg
		Exp. Polystyrene	to 40,000,000 lbs/yr		Under Constr	March 1961	Staff	Staff	Staff
		Desulfurization	6 MMcf	$200,000	Under Constr			Graff	Badger Mfg
		Ortho-Xylene	70,000,000 lbs/yr			Early 1961			
		*Revamp Propylene	2,500,000 gals/yr		Engineering	July 1961		Staff	Staff
CM & M Gas Products	Wise County, Texas	Exp. Gas Processing, Liquid Recovery	150 MMcf	$700,000	Under Constr			Staff	Staff
Diamond Alkali	Deer Park, Texas	*Acetylene			Engineering	Early 1962	Monte-catini	Braun	Braun
Dow Chemical	Freeport, Texas	Acrylonitrile			Planning				
		Styrene-Butadiene Latexes			Engineering	1961			

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
		Exp. Ethylene 67%	.....	.....	Engineering	1961	.....	.....	.....
		Exp. Styrene Monomer	.....	.....	Under Constr	.....	.....	.....	.....
	Plaquemine, La.	Polyethylene	.....	$12,000,000	Under Constr	.....	ICI	.....	.....
Du Pont	Orange,	Polyethylene	.....	.....	Under Constr	.....	.....	.....	.....
	Beaumont,	Caprolactum	50,000,000 lbs/yr	.....	Under Constr	.....	.....	Staff	Staff
	Texas	Acrylonitrile	.....	.....	Under Constr	Spring 1962	Staff	Staff	Staff
Eastern States Petroleum & Chem.	Houston	Exp. Refinery	.....	.....	Planning	.....	.....	.....	.....
El Paso Natural Gas	Terrell County, Texas	Gas Treating	220 MMcf	$4,827,000	Under Constr	1961	.....	Fluor	Fluor
	Pecos County, Texas	Gas Treating	50 MMcf	.....	Planning	.....	.....	.....	.....
El Paso Natural Gas Products	Odessa, Texas	Exp. Styrene	80,000,000 lbs/yr	.....	Under Constr	.....	.....	Staff	Staff
		Ethylene	150,000,000 lbs/yr	.....	Engineering	Late 1961	.....	UOP/Fish	Fish
		*Benzene	15,000,000 gals/yr	.....	.....	July 1961	UOP	UOP/Nofsinger	Chemico
Esso Standard	Baton Rouge, La.	Exp. Butyl Rubber, Stage II	18,000 tons/yr	$8,000,000	Under Constr	Mid 1961	.....	.....	.....
Ethyl	Houston	Vinyl Chloride Monomer	.....	.....	Complete	.....	.....	.....	.....
Firestone	Orange, Texas	Polyisoprene, Polybutadiene	30,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
Goliad/Union Oil of Cal.	Vermillion Parish, La.	Natural Gasoline	450 MMcf	$4,000,000	Under Constr	.....	.....	Fluor	Fluor
	Ascension Parish, La.	LPG Fractionation	20,000 bbls	.....	Under Constr	.....	.....	B & R	Mid-Valley
Goodrich Gulf Chemicals	Port Neches, Texas	Polyolefins, High-Density Polyethylene	13,000,000 lbs/yr	.....	Under Constr	Early 1961	Ziegler	Parsons	Parsons
Goodyear	Beaumont, Tex.	Polyisoprene, Isoprene Polybutadiene	30,000–40,000 tons	.....	Under Constr	Jan 1962	.....	SD	SD
Gulf Oil	Port Arthur	*Delayed Coker	550 tons	.....	Under Constr	Summer 1961	.....	Kellogg	Kellogg
		*Lube Oil Hydrogenation	13,000 bbls	.....	Under Constr	Spring 1961	.....	Bechtel/Staff	Bechtel
		High Purity Ethylene	1,400,000 lbs	.....	Complete	.....	.....	Kellogg/Gulf	Kellogg/Gulf
		Oxo Preparation	.....	.....	Complete	.....	.....	Staff/Treco	Treco
Hercules Powder	Lake Charles, La.	Polypropylene	100,000,000 lbs/yr	.....	Under Constr	1961	Staff	.....	.....
Houston Chemical	Beaumont, Texas	Ethylene Glycol, Ethylene Oxide	8–12,000,000 gals/yr	$12,000,000	Engineering	1961	SD	SD	SD
		*TEL-TML	.....	.....	Engineering	1961	.....	Singmaster & Breyer	Singmaster & Breyer
J.M. Huber	Baytown, Texas	Furnace Blacks	170,000 lbs	.....	Under Constr	1961	.....	Staff	B & R
Humble	Baytown, Texas	Exp. Lub Hydrofiner, Dewaxing, Extraction	6,500 bbls	.....	Under Constr	1961	.....	Fluor	Staft
	Kleberg County, Texas	Gas Process & Cycling	800 MMcf	.....	Complete	.....	.....	Hudson	Hudson
Hunt Oil	Alta Loma, Tex.	Natural Gasoline	.....	.....	Planning	.....	.....	Hudson	Hudson
Hunt Petroleum	Kinder, La.	*Gasoline	24 MMcf	$900,000	Under Constr	Feb 1961	.....	Tears	Tears
Koppers	Port Arthur	Exp. Polyethylene	.....	.....	Complete	.....	Staff	Dalton Hinds & O'Brien	Carruth-Dishman
Mobil Oil	Beaumont, Texas	Ethylene	380,000,000 lbs/yr	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Exp. Polyethylene	12,500 bbls	$2,500,000	Planning	.....	.....	.....	.....
Monsanto Chemical	Gulf Coast	Styrene Monomer	200,000,000 lbs/yr	$30,000,000	Planning	Early 1961	.....	.....	.....
Pan American Pet.	North Cowden, Texas	Exp. Gas Compression	.....	.....	Under Constr	.....	.....	Staff	B & R
	Old Ocean, Texas	Exp. Refinery	.....	.....	Engineering	.....	.....	B & R	B & R
Petroleum Chemicals	Lake Charles, La.	Exp. Ethylene	100,000,000 lbs/yr	.....	Planning	.....	.....	Lummus	.....
Phillips Chemical	Borger, Texas	Exp. Synthetic Rubber	20,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
		Cis-4 Polybutadiene	20,580 tons/yr	.....	Under Constr	1961	.....	Staff	Staff
	Orange, Texas	Carbon Black	60,000,000 lbs/yr	.....	Under Constr	1961	.....	Staff	Stearns Rogers
	Pasadena, Texas	Exp. Polyethylene	to 30,000,000 lbs/yr	.....	Under Constr	1961	.....	Pioneer	Pioneer
		*Polyethylene	5,000,000 lbs/yr	.....	Under Constr	1961	.....	Stearns Roger	Stearns Roger
	Sweeny, Texas	Ethylene	160,000,000 lbs/yr	.....	Under Constr	Mid 1961	.....	Braun	Braun
Phillips Petroleum	Borger, Texas	Heavy Oil Cat Cracking	25,000 bbls	.....	Under Constr	Early 1961	.....	Kellogg	Kellogg
		Natural Gas Liquids	.....	.....	Complete	.....	.....	.....	Staff
	Sweeny, Texas	Exp. Natural Gas Liquids	.....	.....	Under Constr	1961	.....	Braun	Braun
		*Benzene	22,000,000 gals/yr	.....	Under Constr	1961	.....	Procon	Procon
	Stephenville, Texas	*Natural Gasoline	25,000 MMcf	.....	Under Constr	Early 1961	.....	Staff	Staff
	Abbeville, La.	Natural Gas Liquids	45,000 MMcf	.....	Under Constr	1961	.....	Stearns Roger	Stearns Roger
Sid Richardson Carbon	Big Spring, Tex.	Furnace Black	50,000,000 lbs/yr	.....	Under Constr	Mid 1961	United Carbon	B & R	B & R
Runnels Gas Products/Texas Gas Exploration	Eunice, La.	Exp. Extraction	to 800 MMcf	.....	Planning	Jan 1961	.....	Fluor	Fluor
Shell Oil	Sheridan, Texas	Gas Cycling	150 MMcf	$1,000,000	Planning	.....	.....	.....	.....
Shell Chemical	Norco, La.	Acrolein	.....	.....	Under Constr	.....	.....	.....	.....
		Glycerine	.....	$4,500,000	Under Constr	.....	.....	Staff	Parsons/Fluor
Signal Oil & Gas	Houston	Paraxylene Recovery	15,000,000 lbs/yr	$1,500,000	Engineering	1961	.....	Badger Mfg	Badger Mfg
		Fluid Cat Cracker & Light Ends	.....	.....	Under Constr	.....	.....	B & R	B & R
Sinclair-Koppers	Houston	Ethylbenzene, Styrene	70,000,000 lbs/yr	$6,500,000	Under Constr	Mid 1961	Cosden	Badger Mfg	Badger Mfg
Sinclair Refining	Houston	Crude Still	60,000 bbls	.....	Under Constr	Mid 1961	.....	Braun	Braun
		Lube Oil	.....	.....	Under Constr	Spring 1961	.....	Braun	Braun
		Ortho-Xylene	70,000,000 lbs/yr	.....	Under Constr	Spring 1961	.....	Braun	Braun
South Louisiana Production	Jeanerette, La.	Butane, Propane, Other LPG	.....	.....	Under Constr	.....	.....	.....	.....
Sunray Mid-Continent	Bossier Parrish, La.	Exp. Recovery Facilities	500 MMcf	$500,000	Planning	.....	.....	.....	.....
	Benton, La.	*Exp. Natural Gasoline	60 MMcf	$500,000	Complete	.....	.....	Weatherby Eng.	.....
Tennessee Oil	Chalmette, La.	Udex Aromatics Extraction	4,500 bbls	$1,500,000	Engineering	1961	UOP	Badger Mfg	Badger Mfg
		*Ethylbenzene	20 MM lbs/yr	.....	Engineering	Late 1961	Cosden	Badger Mfg	Badger Mfg
	Palacios, Texas	Natural Gasoline	55 MMcf	.....	Under Constr	1961	.....	Olsen	Olsen
Texaco	Paradise, La.	Exp. Plant	.....	.....	Complete	.....	.....	Olsen	.....
	Port Arthur, Texas	Hydrotreater	12,000 bbls	.....	Engineering	Early 1962	.....	Staff	.....
	Lamesa, Texas	*Natural Gasoline	10 MMcf	$700,000	Under Constr	1961	.....	Pona	Pona
Texas Eastman	Longview, Texas	Polypropylene	20,000,000 lbs/yr	.....	Under Constr	.....	.....	Staff	Hudson
Texas-U.S. Chemical	Port Neches, Texas	Exp. Carbon Black-Synthetic Rubber 1/2%	to 156,000 tons/yr	.....	Complete	.....	.....	Tellepsen Petro-Chem Constructors	.....
		*Polybutadiene	20,000 tons/yr	.....	Planning	1962	.....	.....	.....
Transcontinental Gas Pipe Line	Tilden, Texas	Sulfur Recovery	.....	.....	Planning	.....	.....	.....	.....
Union Carbide	Seadrift, Texas	Ester & Alcohol	100,000,000 lbs/yr	.....	Engineering	.....	.....	.....	.....
		Exp. Petrochemicals	.....	.....	Under Constr	.....	.....	Staff	B & R
	Brownsville, Texas	Chemical Solvents, Intermediates	.....	$2,500,000	Under Constr	March 1961	.....	.....	B & R

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Warren Petroleum	Fostoria, Texas	Gas Products Recovery	30,000 MMcf	$600,000	Complete	.....	.....	Staff	Staff
	Fashing, Texas	Gas Processing	75,000 gals	$2,500,000	Complete	.....	.....	Delta Eng	Delta Eng
		Sulfur	50 tons	.....	Under Constr	1961	.....	Graff Eng	Delta Eng
Western Nat. Gas	Brownsville, Texas	Refinery Revamp	3,500 bbls	.....	Under Constr	.....	.....	.....	Staff
		Exp. Refinery	12,500 bbls	$2,500,000	Planning	.....	.....	.....	.....
Wickett Refining	Wickett, Texas	Platformer	1,500 bbls	$350,000	Planning	.....	UOP	J C Hinds	J C Hinds

Rocky Mountain

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Gilsonite	Grand Junction, Colo.	Exp. Coking	1,100 tons	.....	Complete	.....	.....	Staff	.....
Gas Processors	Garland Field, Wyo.	*Sulfur Recovery	14 tons	.....	Under Constr	Feb 1961	Pan American	Tears	Tears
Husky Oil	Cody, Wyo.	Refinery	9,000 bbls	$5,400,000	Under Constr	Early 1961	UOP	UOP	Sweco
Pan American Petroleum/Hondo Oil & Gas	Artesia, N.M.	Natural Gasoline	20 MMcf	.....	Complete	.....	.....	Olsen	Olsen
Phillips	Artesia, N.M.	Natural Gasoline	35,000 MMcf	.....	Complete	.....	.....	Staff	Staff
Standard-Indiana	Casper, Wyo.	Crude Distillation	37,000 bbls	.....	Engineering	1961	.....	Bechtel	Bechtel
Susquehanna Western	Riverton, Wyo.	Exp. Sulfuric Acid	to 75,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
Utah Oil Refining	Salt Lake City,	Exp. Cat Cracker, Alkylation	.....	$1,500,000	Planning	.....	.....	.....	.....

West Coast

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Borden Chemical	San Francisco	Formaldehyde	22,500 tons/yr	.....	Under Constr	.....	.....	.....	.....
Collier Carbon & Chemical, Tidewater Oil	Rodeo, Cal.	Carbon Calcining	.....	.....	Complete	.....	.....	.....	.....
	Los Angeles	*Napthalene	50,000,000 lbs/yr	.....	Planning	Early 1962	Union Oil-Cal	.....	.....
Continental Carbon	Bakersfield, California	Carbon Black	30,000,000 lbs/yr	$2,500,000	Under Constr	Mid 1961	.....	.....	.....
Dow Chemical	Torrance, Cal.	Polypropylene	.....	.....	Under Constr	1961	.....	.....	.....
	Kalama, Wash.	Phenol	36,000,000 lbs/yr	.....	Planning	Mid 1961	.....	.....	.....
Golden Eagle Ref.	Torrance, Calif.	Exp. Refinery	to 30,000 bbls	$35,000,000	Planning	Late 1962	.....	UOP	.....
Hercules Powder	Hercules, Calif.	Methanol	8,000,000 gals/yr	.....	Under Constr	Early 1961	.....	.....	.....
		Formaldehyde	50,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	.....	.....
Richfield Oil	Everett, Wash.	Refinery	.....	$50,000,000	Planning	1965	.....	.....	.....
	Watson, Calif.	Catalytic Reformer	20,000 bbls	$10,000,000	Under Constr	.....	.....	.....	Parsons
Shell Oil	Martinez, Cal.	*Lube Hydrotreater	.....	.....	Engineering	Mid 1961	Shell	Braun	Braun
Standard Oil (Calif.)	Richmond, Cal.	Maleic Anhydride	20,000,000 lbs/yr	.....	Complete	.....	.....	Badger	Badger
		Exp. Polybutene	.....	$3,400,000	Under Constr	1961	.....	Staff	.....
		*Paraxylene	.....	.....	Engineering	1961	.....	.....	.....
		*Orthoxylene	.....	.....	Engineering	1961	.....	.....	.....
		Polymers	.....	.....	Planning	.....	.....	.....	.....
	Honolulu	Refinery	32,000 bbls	$65,000,000	Under Constr	1962	.....	Staff/Bechtel	Bechtel/Hawiian Dredging
Texaco	Los Angeles	Hydrotreater	.....	.....	Under Constr	April 1961	.....	Foster Wheeler	Foster Wheeler
Tidewater Oil	Avon, Cal.	*Hydrocarbon Revamp	.....	.....	Under Constr	1961	UOP	UOP/Braun	Braun
		*Isocracking	20,000 bbls	$20,000,000	Engineering	Mid 1962	Cal Research	Cal Research	.....
Union Oil	Wilmington, Cal.	Catalytic Reformer	14,000 bbls						
		Mid-Barrel Unifiner	20,000 bbls						
		Heavy Cat Unifiner	4,000 bbls	$17,000,000	Under Constr	.....	Staff/Sinclair-Baker	Braun	Braun
		Diesel-Oil Unifiner	10,000 bbls						
		*Cutter Stock Unifiner	.....	.....	Engineering	Mid 1961	Union	Braun	Braun
		CO Boiler	240,000 lbs/hr	$2,500,000	Under Constr	Early 1961	.....	Fluor	Fluor
United Carbon	Southern California	*Carbon Black	175,000 lbs	$5,000,000	Planning	Mid 1961	.....	.....	.....
Valley Nitrogen	Helm, Cal.	Ammonia	150 tons	.....	Engineering	.....	Chemico	Chemico	Chemico
Wilshire	Sante Fe Springs, Cal.	Automatic Gasoline Blending	3,500 bbls/hr	$550,000	Complete	.....	.....	Braun/Staff	Staff
	Norwalk, Cal.	*Refinery Revamp	.....	.....	Engineering	1961	.....	Braun	Braun
Witfield Oil	Watson, Cal.	*Detergent Alkylate	.....	.....	Engineering	Late 1961	Standard-Indiana	Braun	Braun

Canada

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil	Clarkson, Ont.	Compounding, Blending & Grease	.....	$2,900,000	Complete	.....	.....	Nofsinger	Foster Wheeler
		CO Boiler	165,000 lbs/hr	$900,000	Under Constr	Summer 1961	.....	Combustion Engineering/Staff	Combustion Engineering/Staff

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
	Montreal	Udex Aromatics Extraction, Benzene	6,000,000 gals/yr	$2,800,000	Under Constr	Spring 1961	UOP	UOP/Foster Wheeler/Staff	Foster Wheeler
	Moose Jaw, Sask.	Cat Reformer	5,400 bbls	.....	.....	.....	.....	.....	.....
British American Oil, et al	Rimbey, Alta.	Gas Processing	326 MMcf	$10,000,000	Under Constr	1961	.....	Poole-Pritchard Canadian/Staff	Poole-Pritchard Canadian/Staff
British Petroleum	Clarkson	Hydrodesulfurizer	3,500 bbls	$450,000	Engineering	.....	.....	.....	.....
Canadian Chemicals	Edmonton, Alta.	Revamp Petrochemicals	.....	$4,000,000	Under Constr	Jan 1961	.....	Staff/B & R	B & R
		Exp. Refinery	.....	$4,000,000	Planning	.....	.....	.....	.....
Canadian Oil	Carunna, Ont.	Unifiner	5,000 bbls	.....	Under Constr	.....	.....	UOP	Procon
Cities Service Ref.	Trafalgar, Ont.	Distillate Desulfurization	4,000 bbls	$500,000	Under Constr	Early 1961	.....	Procon	Procon/Staff
Colombian Carbon (Canada)	Hamilton, Ont.	Carbon Black	40,000,000 lbs/yr	.....	Engineering	Late 1961	Staff	B & R	.....
Consumers Cooperative Refineries	Regina, Sask.	Naptha Unifiner	3,000 bbls	$3,000,000	Under Constr	1961	UOP	UOP/Staff	Procon Canada
		Platformer	3,000 bbls		Under Constr	1961	UOP	UOP/Staff	Procon Canada
		*Distillate Unifiner	6,000 bbls		Under Constr	1961	UOP	UOP/Staff	Procon Canada
Dominion Rubber	Edmonton, Alta.	Petrochemicals	.....	.....	Engineering	1961	Staff	B & R	B & R
Dow-Canada	Ft. Saskatchewan.	Pentachlor	.....	.....	Engineering	1961	Staff	B & R	B & R
Golden Eagle Refining	St. Johns, Nfld.	*Refinery: Crude Topping Visbreaking Platforming Unifining	7,500 bbls	$5,000,000	Under Constr	July 1961	UOP	Sweco	Lundrigan
Innisfail Operators Committee	Innisfail Field, Alta.	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
		Sulfur Recovery	80 tons	.....	Planning	.....	.....	.....	.....
		Gas Treating	8.7 MMcf	.....	Planning	.....	.....	.....	.....
Irving Refining	St. John, New Brunswick	Hydrogen	.....	.....	Under Constr	.....	.....	Girdler/ Bechtel	Canadian Bechtel
		Gas Treating-Sulfur Recovery	.....	.....	Engineering	.....	.....	Parsons	.....
Jefferson Lake Petrochemicals	Calgary, Alta.	Sulfur Recovery	.....	.....	Under Constr	.....	.....	.....	.....
	Savannah Creek, Alta.	Sulfur Recovery	.....	.....	Under Constr	.....	.....	.....	.....
Monsanto, Canada	Villa La Salle, Que.	Maleic Anhydride	6,000,000 lbs/yr	.....	Planning	.....	.....	SD	SD
Nottingham Gas, Carnduff Gas	Saskatchewan	Gas Processing, Treating, Gathering	8.5 MMcf	.....	Engineering	.....	.....	Tellepsen	Tellepsen
Regent Refining	Port Credit, Ont.	Catalytic Reformer	4,700 bbls	$1,500,000	Complete	.....	.....	UOP	Catalytic
		Benzene	.....	$2,000,000	Under Constr	Fall 1961	UOP	UOP	Bechtel
Sogemines	Maitland, Ont.	Synthetic Nitrogen, Ammonium Nitrate, Nitrogen Solutions, Anhydrous Ammonia	.....	$17,000,000	Engineering	1961	Chemico	Chemico	Chemico
		Partial Oxidation Gasification;	15 MMcf	$1,800,000	Under Constr	1961	.....	Power-Gas	Power-Gas
Texaco, Canada	Montreal	Sulfuric Acid Alkylation, Feed Preparation & Treating	2,200 bbls	$1,800,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
Union Carbide Canada	Montreal East, Quebec	Exp. Ethylene Oxide, Oxide Derivatives 100%	.....	.....	Under Constr	Early 1961	.....	B & R	.....
		Exp. Polyethylene	to 65,000,000 lbs/yr	.....	Under Constr	1961	.....	B & R	.....
Westcoast Transmission	Coleman, Alta.	Gas Processing	.....	$15,000,000	Planning	.....	.....	.....	.....

Latin America

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ARGENTINA									
Argentine Government	Santa Fe	Naphtha Reforming, Aromatics Extraction	6,300 bbls	.....	Planning	.....	.....	.....	.....
	Mendoza	Topping, Delayed Coking, Catalytic Cracking	28,300 bbls	$30,000,000	Under Constr	Nov 1961	Kellogg	Kellogg	Kellogg
	Salta	Naphtha Reforming	3,150 bbls	.....	Planning	.....	.....	.....	.....
	Buenos Aires	Topping, Naphtha Reforming, Lube Oil	20,000 bbls	.....	Planning	.....	.....	.....	.....
Diadema Argentina Shell	Buenos Aires	Crude Still, Fluid Cat Cracker, Feed Preparation, Stabilizer	35,000 bbls	.....	.....	Late 1962	.....	.....	McKee
		Cat Cracker	16,000 bbls	.....	Planning	1962	.....	.....	.....
Esso S.A. P.A.	Campana	Crude Distillation	41,000 bbls	.....	Complete	.....	EREC	Staff	Staff
		Cat Cracker	8,500 bbls	.....	Under Constr	End 1961	EREC	EREC/Kellogg	Tecnastar
Hooker Chemical Atanor	Rio Tercero	Phenol	25 tons	.....	Under Constr	1962	.....	Fish	Fish
Monsanto	Buenos Aires	Phthalic Anhydride	.....	.....	Complete	.....	.....	Foster Wheeler	.....
BRAZIL									
North American Solvay	Sao Paulo	Ethylene Purification	20 tons	.....	Under Constr	.....	.....	Hydrocarbon	Hydrocarbon/ SETAL
Pernambuco State	Pernambuco	Synthetic Rubber	40,000 tons/yr	.....	Planning	.....	.....	.....	.....
Petroleo Brasileiro	Mataripe	Atmospheric & Vacuum Distillation	52,000 bbls	$30,000,000	Under Constr	.....	Kellogg	Kellogg	Kellogg Brasileira/Montreal, SA
		Cat Cracker, Gas Recovery Wax Treating, Lube							
	Rio de Janeiro	Refinery	90,000 bbls	$60,000,000	Under Constr	1961	Houdry/ UOP	Foster Wheeler	.....
	Duque De Caxias Estad. Do Rio de Janeiro	Synthetic Rubber	40,000 tons/yr	.....	Under Constr	1962	.....	Blaw/Knox	.....
	Cubatao-Sao Paulo	Exp. Refinery	110,000 bbls	.....	Under Constr	.....	.....	Petrobras	.....
		Cat Reformer	12,000 bbls						
		Aromatics Extraction	4,750 bbls	$10,000,000	Engineering	Mid 1962	Houdry/ UOP	.....	.....
		Ethane Cracking	3.77 MMcf						
CEN. AMERICA									
Fertilizantes de Centro America (Fertica), et al	Costa Rica	Nitrogen, Potash & Phosphorous Fertilizers, Urea	650 tons	$10,000,000	Planning	.....	.....	.....	.....
Matias de Calves	Puerto Barrios	Refinery	3,500 bbls	.....	Under Constr	.....	.....	Lummus	Lummus
Refineria Petrolera de Guatemala, et al	Matias, de Galves	Refinery	12,000 bbls	.....	Planning	.....	.....	.....	.....
COLOMBIA									
International Petroleum (Colombia)	Cartagena	Ammonia	300 tons	$13,000,000	Engineering	Mid 1962	.....	.....	.....
		Nitric Acid	150 tons						
GUATEMALA									
Breaux Oil Refining	Bridge Puerto Barrios	Refinery	4,000 bbls	.....	Planning	.....	.....	Lummus	Lummus

* First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
MEXICO									
Pemex	Minatitlan	Anhydrous Ammonia	200 tons	$8,000,000	Engineering	Mid 1961	.....	Fluor	Fluor
		Crude	50,000 bbls		Engineering	Mid 1961	.....	Fluor	Fluor
		Cat Reformer	.....	$23,000,000	Engineering	Mid 1961	.....	Fluor	Fluor
		BTX	4,800 bbls		.....	.....	.....	.....	.....
	Salamanco	Anhydrou Ammonia	200 tons	$8,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Topping	40,000 bbls						
		Cat Reformer	.....	$13,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Grease	25 tons	$2,100,000	Engineering	Mid 1961	.....	McKee	McKee
	Ciudad Madero	Refinery	135 000 bbls						
		Cat Cracker	110,000 bbls	$43,000,000	Under Constr	March 1961	.....	McKee	McKee
	Poza Rica	Topping	15,000 bbls	$5,000,000	Under Constr	Mid 1961	.....	McKee	McKee
	Atzcapozalco	Polyethylene	25,000,000 lbs/yr	$8,000,000	Engineering	Late 1961	.....	Simon Carver/ McKee	Simon Carver/ McKee
	Reynosa	Exp. Absorption	6 MMcf	.....	Planning	.....	.....	.....	.....
	Cuidad Pemex	Exp. Absorption	7 MMcf	.....	Planning	.....	.....	.....	.....
Synthesis Organica	Mexico City	Exp. Phthalic Anhydride	.....	.....	Complete	.....	.....	Foster Wheeler	.....
PANAMA									
Refinera Petroquimica de Panama	Portobelo	Refinery	55,000 bbls	$40.000,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
Refineria Panama, SA	Las Minas Bay Colon	Refinery; Petrochemicals	55,000 bbls	$45,000,000	Under Constr	Dec 1961	.....	Kellogg/Bechtel	Bechtel
TRINIDAD									
Shell Trinidad	Port Fortin	Distillation Revamp	14,000 bbls	.....	Under Constr	.....	.....	.....	.....
Texaco Trinidad	Pointe-a-Pierre	Crude Distillation	15.000 bbls	.....	Under Constr	.....	UOP	Procon	Procon
		Crude Topping	100,000 bbls	.....	Under Constr	.....	.....	Fluor	Caribbean Bechtel
		Cat Reformer	15,000 bbls	.....	Under Constr	.....	.....	Fluor	Caribbean Bechtel
		Hydrotreater	20,000 bbls	.....	Under Constr	.....	.....	Staff	Caribbean Bechtel
Administracion Nacional de Combustibles Alcohol Y Portland	La Teja	Vacuum Distillation	10,000 bbls						
		Cat Cracker	5,000 bbls				.....		
		Cat Reformer	3,000 bbls	$10,500,000	.....	.....	.....		
		Gas Concent. & Bottling	.....				.....	Kellogg/Staff	Staff
		Gas Sweetening	4,500 bbls				.....		
		Sulfur Recovery	6 tons				.....		
		Power & Offsite Facilities	3,600 kw	$1,500,000	Under Constr	.....	.....		
		CO Boiler	.....				.....	.....	.....
VENEZUELA									
Creole Petroleum	Amuay Bay	Isopentane	1,800 bbls	$1,500,000	Complete	.....	.....	Esso	Foster Wheeler
Mene Grande Oil	Eastern Venezuela	Compressor Stations	.....	.....	Engineering	.....	.....	B & R	.....
Shell	Lake Maracaibo	*Gas Repressuring	190 MMcf	.....	Under Constr	Early 1961	.....	Foster Wheeler	Foster Wheeler
Venezuela-Gulf Refining	Puerto la Cruz	*HF Alkylation	2,200 bbls	.....	Under Constr	Late 1961	.....	Foster Wheeler	Foster Wheeler

Europe and Africa

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AFRICA									
AE & CI	Modderfontein	Synthetic Ammonia	70,000 tons	.....	Under Constr	.....	.....	Staff/ICI/ Power-Gas	Power-Gas
British Petroleum/ Shell Oil	Durban, Natal	Refinery	.....	$70,000,000	Planning	1963	.....	.....	.....
S.A. Coal, Oil & Gas	.....	Hydrogen	.....	.....	Engineering	.....	Hercules	Power Gas	.....
Societe Nationale Repal	Hassi Er R'Mel, French West Africa	*Gas Separation & Drying	140 MMcf	$2,400,000	Under Constr	March 1961	.....	Technip	Staff
Sociedade Nacional de Refinacao de Petroleos	Lourenco Marques, Mozambique	Refinery:	.....	.....	Under Constr	Early 1961	.....	Procon	Procon
		Crude	12.000 bbls	.....	.....	.....	.....	.....	.....
		Platformer	2,500 bbls	.....	.....	.....	.....	.....	.....
		Unifiner	2,000 bbls	.....	.....	.....	.....	.....	.....
		Merox	1,500 bbls	.....	.....	.....	.....	.....	.....
AUSTRIA									
Power-Gas	Gras	Catalytic Oil Gasification	1.75 MMcf	.....	.....	.....	Power-Gas	Didier	Didier
Oesterreich Mineralolver-Waltung	Schwechat, near Vienna	Crude Distillation	37,000 bbls	.....	Under Constr	.....	.....	Lurgi	Lurgi
		Cat Reformer	7,000 bbls	.....	Under Constr	Jan 1961	UOP	Lurgi	Lurgi
		Gas Recovery	14 MMcf	.....	Under Constr	Mar 1961	.....	Lurgi	Lurgi
		Cat Cracker	10,000 bbls	.....	Engineering	1962	UOP	Comprimo	Voest
BELGIUM									
Amoco Fina	Antwerp	Petroleum Additives	.....	.....	Planning	Early 1961	.....	.....	.....
Cobenam, S.A.	Antwerp	Ethylene	.....	.....	Engineering	1961	S & W	S & W	.....
Raffinerie Belge de Petroles	Antwerp	Gas-Oil Desulfurizer	6,000 bbls	.....	Complete	.....	Institut Francois	Solemca	Solemca
		Two-Stage Vacuum Distillation	5,000 bbls	.....	Complete	.....	Staff	Solemca	Staff
		LPG & Sulfur Recovery	.....	$1,900.000	Under Constr	May 1961	.....	Technip	Oxy France/ Technip
Societe Industrielle Belge des Petroles	Antwerp	*Crude Distillation	100,000 bbls	.....	Under Constr	Early 1962	.....	Foster Wheeler	Foster Wheeler
Union Chemique Belge	Ghent	Phthalic anhydride	5,000 tons/yr	$2,000,000	Under Constr	Early 1961	Sherwin-Williams	Badger NV	Badger NV
CANARY ISLANDS									
Compania Espanola de Petroleos, S.A.	Las Palmas	Ammonium Sulfate	330 tons	$13,000,000	Under Constr	1961	Uhde-Texaco	Uhde	Uhde
	Teneriffe	Crude Distillation	50,000 bbls	$6,000.000	Under Constr	Late 1961	UOP	Procon	Procon
		Unifiner—Platformer	15,000 bbls	$6,000,000	Under Constr	Late 1961	UOP	Procon	Procon
		Boilers, Turbogenerators, tanks,	.....	$6,000,000	Under Constr	1962	AEG &	AEG & VKW	AEG & VKW
		Merox	4,000 bbls	.....	Planning	.....	.....	.....	.....
		Kerosine, Gas Oil, Unifining	10.000 bbls	.....	Planning	.....	.....	.....	.....
		Vacuum Distillation	7,800 bbls	.....	Under Constr	Mid 1961	.....	Foster Wheeler	Foster Wheeler
Compania Insular del Nitrigeno, S.A.	Gran, Canaria	Ammonium Sulfate	330 tons	$10,500,000	Under Constr	.....	Texaco Uhde, Chemibau Linde	Uhde, Man, Chemibau, Linde	Uhde
DENMARK									
Dansk Veedol	Kalundborg	Refinery	20,000 bbls	.....	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
Imperial Chemical Industries	Copenhagen	Polyethylene	.....	$11,200,000	.....	.....	ICI	.....	.....
ENGLAND									
British Chrome & Chemicals	Urlay Nook	Sulfuric Acid	100 tons	.....	Under Constr	.....	Chemiebau	Power-Gas	Power-Gas
British Petroleum	Isle of Grain Kent	Special Solvents: Redistillation, Acid Wash	30,000 tons/yr	.....	Complete	.....	.....	Staff	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British Petroleum California Chemical	Kent	*Orthoxylene *Ethylbenzene *Paraxylene	19,000 tons/yr 16,000 tons/yr 22,000 tons/yr	$19,600,000	Engineering	Late 1961	Cal Research	.....	.....
East Midlands Gas Board	Grimesthorpe	Catalytic Oil Gasification	10 MMcf	.....	Engineering	Oct 1962	Onia Gegi	H & G	H & G
Esso Petroleum.....	Dinnington Milford Haven	Catalytic Oil Gasification Atmospheric Distillation Powerformer Hydrofiner Electric Coalescer Other Auxiliaries	3.5 MMcf 100,000 bbls 16,500 bbls 16,500 bbls 31,500 bbls	.....	Engineering Complete	Late 1961	Onia Gegi	H & G Foster Wheeler	H & G Foster Wheeler
	Fawley	Petroleum Additives Exp. Petrochemicals	.....	.....	Complete Engineering	..... Jan 1961	..... Esso	Foster Wheeler Foster Wheeler	Foster Wheeler Foster Wheeler
Imperial Chemical Industries	Wilton	Polypropylene Ammonium Nitrate Granulation	10,000 tons/yr	.....	Complete	....	..... SBA	....	....
International Synthetic Rubber	Fawley	Synthetic Rubber	90,000 tons/yr	.....	Under Constr	.....	.....	.....	Power-Gas
Mobil International..	Coryton	*Exp. Crude	to 46,500 bbls	$2,000,000	Engineering	1962	.....	.....	.....
Monsanto.....	Newport	Maleic Anhydride	15,000,000 lbs/yr	.....	Under Constr	.....	SD	SD	SD
Northern Gas Board	Darlington	Catalytic Oil Gasification	2 MMcf	.....	Under Constr	.....	.....	Power-Gas	Power-Gas
North Eastern Gas Board	Whitby	Natural Gas Reforming Refinery	1.25 MMcf 75,000 bbls	.....	Under Constr Planning	.....	Hercules	Power-Gas	Power-Gas .....
North Western Gas Board	Ellesmere Port	Gas Reforming	15 MMcf	.....	Engineering	Late 1961	Onia Gegi	H & G	H & G
	Partington	Gas Reforming	12 MMcf	.....	Engineering	Late 1961	Onia Gegi	H & G	H & G
South Eastern Gas...	Isle of Grain	Hydrogen	18 MMcf	.....	Under Constr	.....	.....	Woodall-Duckham	Woodall-Duckham
Southern Gas Board..	Portsmouth	Light Distillate Gasification	2 MMcf	.....	Under Constr	1961	Onia	H & G	H & G
Union Carbide.....	Fawley	Ethylene Oxide & Derivatives	.....	.....	Under Constr	.....	.....	.....	.....
Woodall Duckham....	Fulham	Producer Gas	15 MMcf	.....	Engineering	Oct 1961	H & G	H & G	H & G
FRANCE									
Antar-Petroles del' Atlantique	Donges	Crude Topping	75,000 bbls	.....	Under Constr	July 1961	.....	Technip	Technip
		*Gasoline & Aromatics Superfractionation	163,000 gals	$1,200,000	Under Constr	March 1962	.....	Technip	.....
Californie-Atlantique.	Donges	Paraxylene	.....	.....	Under Constr	Jan 1961	Cal Research	Cal Research	Lummus
Compagnie Francaise de Petrole/ CompagnieFrancaise de Raffinage/ Pechelbronn	Strasbourg	Refinery	70,000 bbls	.....	Planning	.....	.....	.....	.....
Esso Francaise.....	Port Jerome	*Aromatics Extraction	.....	.....	Under Constr	Early 1962	.....	Foster Wheeler	Foster Wheeler
Ethyl Synthese.....	Lillebonne	*Monomer Styrene	25 to 30,000 tons/yr	.....	.....	.....	Koppers	SBA	.....
Esso Standard.....	Port Jerome	Lube Hydrofiner	4,000 bbls.	.....	Under Constr	1961	Esso R & E	Esso Lummus	Lummus
		*Paraxylene, Orthoxylene, Solvents	44,500 tons/yr	.....	Engineering	1962	Esso	Esso	.....
Houilleres du Bassin de Lorraine	Carling	Nitric Acid	.....	.....	Engineering	.....	SBA	SBA	SBA
Naphtachimie.....	Lavera	Exp. Ethylene Oxide	60,000,000 lbs/yr	.....	Under Constr	.....	S D	SFST	SFST
		Exp. Butadiene Recovery	8,000 tons/yr	.....	Planning	.....	.....	Foster Wheeler	Foster Wheeler
		Cat Cracking, Gas Separation	.....	.....	Under Constr	.....	.....	S & W	S & W
		Ethylene Glycol	.....	.....	Under Constr	.....	.....	Naphthachimie	.....
		Polyisobutene	.....	.....	Engineering	Summer 1961	Cosden	Badger France	Badger France
		Propylene Oxide	.....	.....	Under Constr	.....	.....	Naphthachimie	.....
		Propylene	.....	$1,000,000	Under Constr	Spring 1961	.....	Badger NV/ Badger France	Badger France
Societe des Produits d'Aquitaine	Chimique	Ammonia	200 tons	$6,000,000	Engineering	.....	.....	Chemico	Chemico
	Lacq	Acetylene from Nat. Gas	75 tons	.....	Under Constr	.....	BASF	BASF/Heurtey	Heurtey
Soc. Nationale des Petroles D'Aquitaine	Lacq	Desulfurization	175 MMcf	.....	Under Constr	.....	.....	Foster Wheeler	Staff
		Natural Gasoline	120 MMcf	.....	Under Constr	1961	.....	Lummus	Staff
		*DEA Washing	140 MMcf	$1,000,000	Under Constr	April 1961	.....	Technip	Staff
		Ethylene	25,000 tons	.....	Under Constr	.....	.....	Hydrocarbon	Staff
		Preliminary Desulfurization	350 MMcf	.....	Under Constr	1961	.....	Technip	Staff
Soc. Vinylacq	Lacq	Vinyl Chloride	.....	.....	Planning	.....	.....	.....	.....
United Carbon.....	Roue	Carbon Black	50,000,000 lbs/yr	$5,000,000	Planning	1961	.....	.....	.....
EAST GERMANY									
DIA Chemie Ausruestung Berlin	Leuna	Ethylene Aromatics	40,000 tons/yr	$12,000,000	Engineering	1962	Petrocarbon	Petrocarbon/ H & G	Staff/H & G
Leuna-Werk Walter Ulbricht	.....	Urea	.....	.....	Planning	.....	.....	.....	.....
	.....	Ammonium Nitrate	.....	.....	Planning	.....	.....	.....	.....
	.....	Exp. Nitrogen	to 400,000 tons/yr	.....	Planning	1965	.....	.....	.....
Piersteritz Nitrogen..	.....	Exp. Nitrogen	to 20,000 tons/yr	.....	Planning	1961	.....	.....	.....
WEST GERMANY									
B.P. Benzin und Petroleum	Dinslaken	Distillation, Cat Reforming Hydroforming Copper Chloride Treaters Sulfur Plant	100,000 10,000 10,000 4,800 12 Tons	.....	Complete	.....	.....	Kellogg	Fried Krupp
		*Cat Cracker	10,000 bbls	.....	Under Constr	1961	.....	.....	.....
		*Copper Chloride	4,000 bbls	.....	Under Constr	1961	.....	.....	.....
		*Bitumen	100,000 tons/yr	.....	Under Constr	1961	.....	.....	.....
British Petroleum, California Chemical	Dinslaken	*Orthoxylene *Ethylbenzene *Paraxylene	19,000 tons/yr 16,000 tons/yr 22,000 tons/yr	$19,600,000	Engineering	Late 1961	.....	.....	.....
Chemische Fabrik Holten	Lubwigshaven a Rein	Ethylene Oxide	9,000,000 lbs/yr	.....	Under Constr	.....	S D	S D	.....
Chemische Werke Huls	Marl	Polyethylene	6,000 tons/yr	.....	Planning	.....	Ziegler	Staff	Staff
		*Polybutadiene	20,000 tons/yr	.....	Planning	1963	.....	Staff	.....
		*Exp. Polyvinylchloride	to 80,000 tons/yr	.....	Under Constr	1961	.....	Staff	.....
		*Exp. Polystyrene	to 30,000 tons/yr	.....	Under Constr	1961	.....	Staff	.....
Deutsche Erdoel....	Heide	Exp. Refinery	50,000 bbls	.....	Engineering	1962	.....	Edeleanu/Staff	.....
Durag-Nerag.....	Misburg, Hannover	Unifiner, Platformer, Sulfur Recovery	4,500 bbls	.....	Complete	.....	UOP	Lurgi	Lurgi
		Crude Distillation, Thermal Cracker	21,000 bbls	.....	Under Constr	1961	.....	Lummus	Lummus
Deutsche Shell.....	Harburg	Refinery: Crude Distiller Cat Reformer Hydrodesulfurization	40,000 bbls	.....	Under Constr	.....	.....	Lummus	.....
	Godorf	Refinery	40,000 bbls	.....	Completed	.....	.....	.....	.....
Erdolchemie.....	Dormagen/ Niederrhein	Propylene Oxide	20,000 tons/yr	.....	Under Constr	.....	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer
		Ethylene	30,000 tons/yr	.....	Under Constr	.....	.....	S & W	S & W
		Ethanol	18,000 tons/yr	.....	Under Constr	.....	Shell	S & W	S & W
		Butadiene	30,000 tons/yr	.....	Under Constr	.....	Esso	Lurgi	Lurgi
		Gasoline Selective Hydrogenation	120,000 tons/yr	.....	Under Constr	.....	BP	BP/Lurgi	Lurgi
		Di-isobutane	30,000 tons/yr	.....	Engineering	1961	Farbenfabriken	Lurgi	Lurgi
Esso A.G.....	Koln	Steam Cracker, Ethylene Recovery, Petrochemicals	5,000 bbls	$11,000,000	Under Constr	June 1961	Esso R & E	Lurgi	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
	Karlsruhe	*Refinery	68,000 bbls	.....	Engineering	Late 1962	.....	.....	.....
Gelsenberg Benzin AG	Gelsenkirchen	Platformer	12,500 bbls	$5,300,000	Under Constr	.....	UOP	Lurgi	.....
Gewerkschaft Erdolraffinerie Emsland	Lingen Holthausen	Unifiner-Platformer	4,700 bbls	.....	Planning	.....	UOP/Shell	Lummus	Lummus
		Gas Oil Desulfurizer	5,500 bbls	.....	Planning	.....	UOP/Shell	Lummus	Lummus
Frisia	Emden	Refinery	30,000 bbls	$17,000,000	Engineering	.....	.....	Parsons	Parsons
Ministry of Coal & Energy	Stralsund	Catalytic Oil Gasification	4.8 MMcf	.....	Under Constr	.....	Power-Gas	Power-Gas/Didier	Didier
Olewerke Julius Schindler	Hamburg-Neuhof	Solvent Dewaxing	2,500 bbls	$4,000,000	Under Constr	Early 1961	Edeleanu	Edeleanu	Edeleanu
Kali-Chemie	Bad Honningen	Hydrogen	.....	.....	.....	.....	Hercules	Power-Gas	Power-Gas
Rheinische Olefinwerke	Wesseling Bez. Koln	Ethylene	75,000 tons	.....	Under Constr	1961	.....	Braun	Staff
		Ethylene	.....	.....	Engineering	Jan 1961	Kellogg	Braun/Lurgi	.....
Ruhrchemie	Oberhausen-Holten	Polyethylene	.....	.....	Under Constr	.....	Staff	Uhde	Staff/Uhde
Westdeutsch Erdolleitungs	Ruhlermoor	Crude Desalter	5,700 bbls	.....	Engineering	.....	Howe-Baker	Uhde	Uhde
Wintershall, A.G.	Salzbergen	Atmospheric Vacuum Distillation	300 tons	.....	Under Constr	.....	Lummus	Lummus	Lummus
GREECE									
Dow Chemical	.....	Polystyrene Plastic	.....	$1,000,000	Planning	Early 1961	.....	.....	.....
Greek Government	Ptolemaeus	Ammonia	300 tons	.....	Engineering	Mid 1962	Uhde, Casale	Uhde, Casale	Uhde, Casale
		Ammonium Sulfate	525 tons						
		Ammonium Nitrate	325 tons						
	Aspropygas	LPG	25,000 tons/yr	.....	Planning	.....	.....	.....	.....
IRELAND									
Cork Gas Consumers	Cork	*Light Distillate Gasification	3 MMcf	.....	.....	1961	Onia Gegi	H & G	H & G
ITALY									
Asfalti BitumiCementie Derivati, S.A.	Ragusa	*Exp. Polyethylene	to 80 tons	.....	Under Constr	.....	.....	.....	.....
Azienda Nazionale Idrogenazione Combustibil	Ravenna	Butadiene	22,000 tons/yr	.....	Engineering	.....	Houdry	Catalytic	.....
		Ethylene	.....	.....	Under Constr	.....	Koppers	ANIC	.....
	Gela, Sicily	Refinery	.....	.....	Under Constr	1962	.....	.....	.....
Dow Chemical Italiana	.....	Polystyrene	.....	.....	Planning	.....	.....	.....	.....
Industria Raffinazione Oli Minerali	Venice	*Cat Reformer	4,000 bbls	.....	Under Constr	Mid 1961	UOP	UOP/SNAM Progetti	SNAM Progetti
Montecatini Societe Generale per l'Industria Mineraria Chimica	Ferrara	Exp. Polypropylene	2,200,000 lbs/yr	.....	Under Constr	.....	S D	S D	.....
	Castellanza	Exp. Formaldehyde	.....	.....	Planning	.....	.....	.....	.....
	Brindisi	Petrochemical	135,000,000 lbs/yr	$300,000	Under Constr	.....	.....	.....	.....
			700,000 tons/yr	$95,000,000	Under Constr	1962	.....	.....	.....
Phillips Petroleum & ANIC	.....	Carbon Black	25,000,000 lbs/yr	.....	Planning	1962	Phillips	.....	.....
Purfina Italiana	Rome	Refinery	20,000 bbls	$10,000,000	Planning	1962	.....	.....	.....
	Genoa	Topping Revamp	13,000 bbls	$500,000	Under Constr	1961	.....	Staff	Staff
		Trickle Hydrodesulfurization	2,200 bbls	$350,000	Engineering	1961	Shell	CTIP	Staff
Sincat	Priolio, Sicily	Ethylene	2,200 bbls	$500,000	Engineering	1961	Shell	CTIP	Staff
		Treating	.....	.....	Under Constr	.....	S & W	S & W	.....
Snia Viscosa	Varedo, near Milan	Carbon Disulfide	.....	.....	Engineering	.....	.....	S & W	.....
			.....	.....	Under Constr	.....	Food	.....	.....
Union Carbide Societa Edison S.A.	Sicily	Polyethylene	.....	.....	.....	.....	.....	.....	.....
	Celene	Ethylene Oxide	15,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
Malta Gas Board	Valetta	Catalytic Oil Gasification	26,500,000 lbs/yr	.....	Under Constr	.....	.....	.....	.....
			1 MMcf	.....	Under Constr	.....	.....	Power-Gas	Power-Gas
NETHERLANDS									
N.V. Mattschappij Tot Exploitatie Van Kooksovengossen	Ijmuiden	Gas Reforming	4.4 MMcf	.....	Under Constr	.....	.....	.....	.....
		CO Conversion	.....	.....	Planning	.....	.....	.....	.....
Staatsmijner in Limburg	Geleen, Holland	Phthalic Anhydride	.....	.....	Under Constr	1960-1961	S D	SFST	.....
NORWAY									
A/S Esso-Raffineriet, Norge	Slagentangen (Oslo Fjord)	Refinery	40,000 bbls	.....	Under Constr	1961	Esso	Bechtel	Bechtel-Sverdrup
POLAND									
Polimex	Oswiecim	Polystyrene	35,000 bls	$1,500,000	Under Constr	.....	Petrocarbon	Petrocarbon	Staff
Polish Government	Plock	Refinery	40,000 bbls	.....	Planning	1965	.....	.....	.....
		Hydrogen	1.5 MMcf	.....	.....	.....	.....	.....	.....
		Fuel Gas	11 MMcf	.....	.....	.....	.....	.....	.....
RUMANIA									
Rumanian Govt.	Teleajen	Lube Oil	.....	.....	Planning	.....	.....	.....	.....
		Natural Gas Treating	.....	.....	Planning	.....	.....	.....	.....
	Borzesti	Petrochemical	.....	.....	Planning	.....	.....	.....	.....
	Onesti	Synthetic Rubber	.....	.....	Planning	.....	.....	.....	.....
SCOTLAND									
Forth Chemicals	Grangemouth	Exp. Styrene Monomer	50,000 tons	.....	Under Constr	1961	Monsanto	Monsanto	Matthew-Hall
British Hydrocarbon Chemicals	Grangemouth	Methanol	.....	.....	Under Constr	1961	.....	Chemico	Chemico
		Butadiene	.....	.....	Under Constr	1961	Esso	Fluor	Fluor
		Ethylene Dichloride	.....	.....	Under Constr	1961	Ethyl	Lummus	Lummus
Scottish Gas Board	Fifeshire	Stage 1 Pressure Gasification	15 MMcf	$18,000,000	.....	1961	Lurgi et al	H & G	H & G
		Stage 2, Pressure Gasification	15 MMcf	.....	Engineering	.....	Lurgi. et al	H & G	H & G
SOUTH AFRICA									
AE & CI	Modderfontein	Synthetic Ammonia	70,000 tons	.....	Under Constr	.....	.....	Staff/ICI/Power-Gas	Power-Gas
Phillips Petroleum-Industrial Development	.....	Carbon Black	22,000,000 lbs/yr	.....	Under Constr	.....	Staff	Staff	Staff
Standard Vacuum	Durban	Exp. Asphalt Oxidizer	2,100 bbls	$415,000	Under Constr	.....	.....	Staff	.....
			600 bbls						
SPAIN									
Repesa	Escombreras (Cartagena) Spain	Ammonia	325,000,000 lbs	$32,000,000	Engineering	1962	Texaco/Giammareo/	Foster Wheeler	Foster Wheeler
		Ammonium Sulfate	600,000 tons					Uhde	Uhde
		Urea	210,000 tons					Chemico/Dorr-Oliver	Chemico/Dorr-Oliver
SWITZERLAND									
Miranco	Mendrisio	Lube Oils	500 bbls	$1,500,000	Under Constr	.....	.....	Staff	.....
Power-Gas	Winterthur	Catalytic Oil Gasification	606 MMcf	.....	Under Constr	.....	Power-Gas	Power-Gas Didier	Power-Gas Didier
U.S.S.R.									
Techmachimport	Angarsk, Siberia	Acetylene	.....	.....	Engineering	.....	SBA	SBA	SBA
		Synthetic Ammonia	.....	.....	Engineering	.....	SBA	SBA	SBA
YUGOSLAVIA									
Yugoslav Govt.	Sisak	Topping	15,000 bbls	$10,000,000	Planning	Spring 1963	.....	.....	.....
		Delayed Coking	4,950 bbls						
		Platforming	3,020 bbls						

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
	Kutina	Ammonia	.....	.....	Planning	.....	.....	.....	.....
Yugoslavian Govt....	Zagreb	Petrochemicals	.....	.....	Planning	Mid 1962	.....	Foster Wheeler	Foster Wheeler
	Rijeka	Topping	1,000,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Naphtha Rerunning	140,000 tons/yr						
		Platforming	100,000 tons/yr						
		Sulfur Recovery	5,000 tons/yr						
	Bosanski Brod	Topping	640,000 tons/yr	.....	Planning	.....	.....	.....	.....

Near East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ALGERIA									
Cie Francaise des Petroles	Algiers	Refinery	44,000 bbls	.....	Engineering	1962	.....	.....	.....
EGYPT									
Anglo-Egyptian Oilfields	Suez	Cat Reformer	2,300 bbls	.....	Planning	.....	.....	.....	.....
Egyptian Chem. Ind./ KIMA S.A.E.	Aswan	Ammonia	415 tons	.....	Under Constr	.....	Uhde/ BASF	Uhde/BASF	Uhde/BASF
Egyptian Government	Suez	Atmos. Distillation Vac. Distillation & Lube Oils	20,000 bbls	$7,000,000	Planning	.....	.....	.....	.....
		Cat Reformer	3,000 bbls	$2,700,000	Planning	1962	.....	.....	.....
		Hydrodesulfurizer	2,700 bbls	$720,000	Planning	1962	.....	.....	.....
		Lube Oils	.....	$9,000,000	Planning	1963	.....	.....	.....
	Alexandria	Atmos. & Vacuum Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	Atmos. & Vacuum Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
IRAN									
Iranian Govt.....	Shiraz	Nitric Acid	30,000 tons/yr	$30,000,000	Under Constr	.....	SBA	SBA/Foster Wheeler	CJB
		Ammonium Nitrate	.....	.....	Under Constr	.....	SBA	SBA/Foster Wheeler	.....
Iranian Oil.....	Abadan	*Cat Reformer	20,000 bbls	.....	Engineering	Early 1962	UOP	Fluor	Fluor
IRAQ									
Iraq Petroleum.....	Kirkuk	Oil Sweetening	250,000 bbls	$1,250,000	Under Constr	Sept 1961	.....	Foster Wheeler	Foster Wheeler
		Oil Sweetening	400,000 bbls	.....	Planning	Jan 1962	.....	Staff/Foster Wheeler	Foster Wheeler
KUWAIT									
Kuwait Oil.....	Mina al Ahmadi	Bulk LPG	8,000 bbls	.....	Engineering	1961	.....	Wimpey-Bechtel International	Wimpey-Bechtel
MOROCCO									
Ente Nazionale Idrocarburi	Mohammedia	Refinery	25,000 bbls	.....	Under Constr	1962	.....	.....	.....
PAKISTAN									
Pakistan Industrial Development	Fnchanj	Ammonia	225 tons	$20,000,000	Engineering	1961	Kobe Steel	Chemico	Chemico
		Urea	375 tons	.....	.....	.....		.....	.....
Standard Vacuum Oil, et al	Korangi	Refinery: Crude Distillation, Hydrotreater, Catalytic Reformer	32,000 bbls	$35,000,000	Engineering	.....	.....	.....	.....
Sui Carbon.....	.....	Carbon Black	36,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
SAUDI ARABIA									
Arabian American Oil	Ras Tanura	Alkylation	1,210 bbls	$6,000,000	Complete	.....	Kellogg	Kellogg/Staff	Staff
		LPG	1,500 bbls	$1,025,000	Engineering	1961	Kellogg	Staff	Staff
		Asphalts	.....	.....	Under Constr	.....	.....	.....	.....
		*Refrigerated LPG	4,000 bbls	$6,600,000	Under Constr	1961	.....	Staff	Staff
United Arab Republic	Suez	Exp. Refinery	.....	.....	Engineering	.....	UOP/ Others	Braun	.....
Arabian Oil of Japan..	Kuwait	Topping & Utilities	20,000 bbls	.....	Planning	1962	.....	.....	.....
		Refinery	50,000 bbls	.....	Planning	1965	.....	.....	.....
TURKEY									
Caltex, Standard Oil (Calif.), Turkish Govt.	Izmit	Refinery: Crude Distillation, Naphtha Unifiner, Platformer, Distillate Hydrotreater, Catalytic Cracker	20,800 bbls	$26,000,000	Under Constr	.....	.....	Kellogg	Kellogg
Caltex.....	Mersin	Refinery:							
Mobil International, Royal Dutch Shell BP		Crude Distillation, Naptha Pretreating, Naptha Catalytic Reforming, Kerosine Catalytic Hydrodesulfurization	65,000 bbls	$48,000,000	Under Constr	End 1961	.....	Foster Wheeler	Foster Wheeler

Far East

FORMOSA									
Chinese Petroleum....	Kaohsiung	Unifiner	5,500 bbls	$900,000	Engineering	.....	Union Oil	Fluor/Staff	Staff
		Catforming	5,000 bbls	.....	Planning	.....	.....	.....	.....
Pioneer Chemical.....	Taipei	Coal Tar Distillation	36 tons	.....	Engineering	.....	.....	Ishii Iron Works	.....
INDIA									
Fertilisers & Chemicals Travancore	.....	Partial Oxidation Gasification	.....	.....	Engineering	.....	Texaco	Power-Gas	Power-Gas
		Carbon Monoxide Pressure Conversion	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas
		Carbon Dioxide & Hydrogen Sulfide Removal	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas
	Barauni	Refinery	40,000 bbls	.....	Planning	1962	.....	USSR Govt	USSR Govt
Neyveli Lignite.....	Neyveli	Urea	500 tons	$52,500,000	Engineering	Early 1963	.....	Montecatini/ Ansaldo	Montecatini/ Ansaldo
Oil India Private.....	Noonmati, Assau	Refinery	750,000 tons/yr	$10,500,000	Under Constr	April 1961	Indian Govt	Rumanian Govt	Rumanian Govt
Phillips Carbon Black	Durgapur	Carbon Black	22,000,000 lbs/yr	.....	Under Constr	Late 1961	.....	.....	.....
Sahu Chemicals.....	Varanasi	Ammonium Chloride	120 tons	.....	Under Constr	.....	Uhde	Uhde	Uhde
		Ammonia	120 tons	.....	Under Constr	.....	John Thompson	CECIP	John Thompson
Standard Vacuum....	Bombay	Asphalt	125,000 tons/yr	$2,500,000	Under Constr	.....	.....	Parsons	Parsons
INDONESIA									
Indonesian Govt.....	Palembaug, Sumatra	Urea Fertiliser	330 tons	.....	Complete	.....	.....	Foster Wheeler	Foster Wheeler

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
JAPAN									
Asahi Chemical Industries	Nobeoka	NH_3 Synthesis Gas	50 metric tons	$3,670,000	Under Constr	.....	Texaco/ Chemico	Chemico	Chemico
Asia Oil	Yokohama	Unifiner	3,000 bbls	$1,000,000	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	$3,770,000	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		Merox	4,000 bbls	$119,000	Engineering	Feb 1961	UOP	UOP/JGC	JGC
		Topping Desalter	30,000 bbls	$1,980,000	Engineering	Feb 1961	.....	Chiyoda	Chiyoda
		Gas Concentration	1.6 MMcf	$511,000	Engineering	Sept 1961	.....	UOP/JGC	JGC
Daikyo Oil	Yokkaichi	Merox	6,000 bbls	.....	Under Constr	.....	UOP	UOP/JGC	JGC
		*Furfural	15,000 bbls	$835,000	Planning	Nov 1961	Texaco	Texaco/Chiyoda	Chiyoda
Furukawa Chemical Industries	Japan	Platforming	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	.....
Fuji Iron & Steel	Himeji	Unifining, Udex	700 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
General Oil	Kawasaki	Merox	5,700 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		*Desalter	30,000 bbls	$100,000	Complete	.....	Petreco	Petreco/ Chiyoda	Chiyoda/Staff
		*Electrofiner	3,000 bbls	$70,000	Complete	.....	Petreco	Petreco/ Chiyoda	Chiyoda/Staff
General Sekiyu	Kawasaki	*Merox	6,000 bbls	.....	Under Constr	1961	UOP	UOP/JGC	JGC
		*Unifiner-Platformer	6,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Idemitsu Kosan	Tokuyama	*Unifiner-Platformer	5,000 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
		*Merox	7,000 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
	Chiba	*Unifiner-Platformer	9,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Merox	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Japan Synthetic Rubber	Yokkaichi	*Exp. Synthetic Butadiene Rubber	5,000 tons/yr	.....	Engineering	Dec 1961	Goodyear	JGC	JGC
		*Exp. Butadiene	5,000 tons/yr	.....	Engineering	Oct 1961	Esso	JGC	JGC
		*Butyl Rubber	5,000 tons/yr	.....	Planning	March 1962	Esso	.....	.....
		*Iso-Butylene	30,000 tons/yr	.....	Planning	Dec 1962	.....	.....	.....
		*Cis-Polybutadiene	.....	.....	Planning	.....	.....	.....	.....
Koa Oil	Iwakuni	Delayed Coker	4,500 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
		Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		*Topping-Vacuum	55,000 bbls	$42,000,000	Under Constr	April 1961	.....	JGC	JGC
		*Unifining	10,000 bbls	.....	Planning	Early 1962	UOP	UOP/JGC	JGC
		*Udex	2,500 bbls	.....	Planning	Late 1962	UOP	UOP/JGC	JGC
	Marifu	*Crude	40,000 bbls	.....	Engineering	March 1961	UOP	JGC	JGC
Kokan Chemical Industries	Kawasaki	Ethylbenzene	21,000 tons/yr	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		Styrene Monomer	13,000 tons/yr	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
Kyowa Fermentation Industry Co., Ltd.	.....	Acetaldehyde	45 tons	.....	Planning	.....	Knapsack-Griesheim	Uhde	Uhde
	Ube	Butanol, Octanol, Acetylene, Ethylene	.....	$13,500,000	Planning	.....	.....	Iion-Tears	Iion-Tears
			.....	$6,500,000	Planning	.....	.....	.....	.....
Kyowa Gas	Nigatta	*Acetylene	60 tons	.....	Engineering	Early 1962	BASF	Chemico	Staff
		*Methanol	220 tons	.....	Engineering	Early 1962	Chemico	Chemico	Staff
Maruzen Oil	Matsuyama	Unifiner	4,000 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
		Udex	1,500 bbls	.....	Under Constr	Feb 1961	UOP	UOP/JGC	JGC
	Shimotsu	Unifiner-Platformer	6,000 bbls	.....	Under Constr	Feb 1961	UOP	UOP/JGC	JGC
		Unifiner	4,500 bbls	.....	Under Constr	April 1961	UOP	UOP/JGC	JGC
Mitsubishi Oil	Mizushima	*Desalter	22,000 bbls	$3,000,000	Under Constr	April 1961	Petreco	Petreco/ Chiyoda	Chiyoda
		*Atmospheric & Vacuum Crude Distillation	22,000 bbls					Chiyoda	Chiyoda
		Unifiner-Platformer	3,600 bbls	$1,400,000	Engineering	Sept 1961	UOP	Chiyoda/ JGC/UOP	Chiyoda
		*Unifiner	7,200 bbls	$800,000	Engineering	Sept 1961	UOP	Chiyoda/ JGC/UOP	Chiyoda
		Merox	2,000 bbls	$140,000	Engineering	April 1961	UOP	Chiyoda/ JGC/UOP	Chiyoda
		Unifiner	4,200 bbls	$1,260,000	Planning	Feb 1962	UOP	Chiyoda/ JGC/UOP	Chiyoda
		*Hydogen	5,900,000 scf	$1,480,000	Planning	March 1962	.....	Chiyoda	Chiyoda
		*Cat Cracking	7,600 bbls	$2,710,000	Planning	Feb 1962	.....	Chiyoda	Chiyoda
		*Fluid Coker	5,600 bbls	$3,720,000	Planning	March 1962	Esso	Chiyoda/Esso	Chiyoda
		*Gas Recovery	801,000 lbs	$2,300,000	Planning	Feb 1962	.....	Chiyoda	Chiyoda
		*Sulfur Recovery	62 Metric tons	$680,000	Planning	March 1962	.....	Chiyoda	Chiyoda
		*H_2S Scrubber	171,000 lbs	$380,000	Planning	March 1962	.....	Chiyoda	Chiyoda
	Kawasaki	*Stabilizer & Depropanizer	5,000 bbls	$280,000	Engineering	June 1961	.....	Chiyoda	Chiyoda
		Refinery	22,000 bbls	$40,000,000	Under Constr	Early 1962	.....	.....	Chiyoda/JGC
Mitsubishi Petrochemical	Yokkaichi	Unifiner-Udex	1,606 bbls	.....	Under Constr	June 1961	UOP	UOP/JGC	JGC
		Ethylene	22,000 tons/yr	.....	Under Constr	July 1961	S & W	S & W/JGC	JGC
		Polyethylene	41.1 tons	.....	Under Constr	July 1961	BASF	BASF/Mitsubishi Chemical Machinery	Mitsubishi Chemical Machinery
		*Styrene Monomer	15,000 tons/yr	.....	Under Constr	1961	.....	Chiyoda	Chiyoda
Mitsui Petrochemicals	Otake	*Ethylene	20,000 tons/yr	.....	Engineering	.....	S & W	S & W/Mitsui Ship Bldg.	Mitsui Ship Bldg.
New Asia Oil	Yokohama	*Atmospheric Crude Distillation	30,000 bbls	$1,600,000	Under Constr	Feb 1961	.....	Chiyoda	Chiyoda
		*Merox	4,000 bbls	.....	Engineering	Feb 1961	UOP	UOP/JGC	JGC
		*Stabilizer	4,000 bbls	$170,000	Under Constr	Feb 1961	.....	Chiyoda	Chiyoda
		*Desalter	30,000 bbls	$100,000	Under Constr	Feb 1961	Petreco	Petreco, Chiyoda	Chiyoda
		*Unifiner	3,000 bbls	.....	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		*Unifiner-Platformer	5,000 bbls	.....	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		*Gas Concentration	1.6 MMcf	.....	Engineering	Aug 1961	UOP	UOP/JGC	JGC
	Hakodate	*Vacuum	1,000 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
Nichimo Oil	Kawasaki	*Electrofiner	1,900 bbls	$40,000	Complete	.....	Petreco	Petreco/ Chiyoda	Chiyoda/Staff
Nihon Synthetic Rubber	Yokkaichi	Exp. Petrochemicals	to 45,000 tons/yr	.....	Under Constr	1963	.....	.....	.....
Nippon Mining	Mizushima	Unifiner	2,000 bbls	.....	Under Constr	June 1961	UOP	UOP/JGC	JGC
		Unisol	2,500 bbls	.....	Under Constr	June 1961	UOP	UOP/JGC	JGC
		Cat Reforming	6,000 bbls	.....	Under Constr	June 1961	Houdry	Houdry	Houdry
		Hydrodesulfurization	8,000 bbls	.....	Under Constr	June 1961	.....	Catalytic/ Niigata	Catalytic/ Niigata
		*Crude Distillation	30,000 bbls	.....	Under Constr	June 1961	.....	Fujinagata	Fujinagata
Nippon Petrochemicals/Oronite Chemical	Kawasaki	Alkyl Benzene	15,000 tons	$4,000,000	Engineering	Late 1961	Cal Research	Standard-Cal	Niigata
		Unifiner-Udex	800 bbls	$3,700,000	Engineering	Aug 1961	UOP	UOP/JGC	UOP/JGC
		Isopropanol	6,000 tons/yr						
		Acetone	6,000 tons/yr	$2,500,000	Planning	June 1961	Distiller	S & W	.....
Nippon Petroleum Refining	Yokohama	Cat Cracker	7,500 bbls	.....	Under Constr	June 1961	UOP	UOP/JGC	JGC
Nilto Chemical Industry	.....	Synthesis Gas	125 tons	$6,000,000	Planning	.....	Texaco	Iino-Tears	Iino-Tears
Osaka Gas	Hokko	Catalytic Oil Gasification	20 MMcf	$1,800,000	Under Constr	1961	Onia Gegi	H & G	Ishii Iron
Showa Denko KK	Tokyo	Carbon Black	.....	.....	Under Constr	.....	Phillips	.....	.....
Showa Oil	Kawasaki	Unifiner-Platformer	6,000 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		Merox	4,000 bbls	.....	Engineering	Aug 1961	UOP	UOP/JGC	JGC

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Sumitomo Chemical/ SBA	Niihama City	Acetylene-Ethylene	.....	.....	Engineering	.....	SBA	SBA	.....
		*Ethylene	25,000 tons/yr	.....	Planning	.....	S & W	.....	.....
Toa Oil	Kawasaki	*Desalter	30,000 bbls	$100,000	Planning	July 1961	Petreco	Petreco/ Chiyoda	JGC/Chiyoda
		*Merox	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Tokai Ryuan K.K.K.	.....	High Pressure H_2S & CO Conversion, CO_2 Removal	500,000 cu ft/hr	.....	Engineering	.....	Power-Gas/ Ventrocoke	Power-Gas	.....
Toyo Koatsu	Shimonoseki	Ethanolamines	150 tons	.....	Complete	.....	Staff/JGC	Staff/JGC	JGC
	Muroran	*Alkar	17,250 tons/yr	.....	Planning	May 1962	UOP	UOP	.....
		*Styrene	15,000 tons/yr	.....	Planning	May 1962	UOP	UOP	JGC
Ube Kosan	.....	Ammonia	100 tons	.....	Under Constr	.....	.....	Chemico	Chemico
		Ethylene	21,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Polyethylene	20,000 tons/yr						
		Polypropylene	5,000 tons/yr						
KOREA									
Korean Government	Naju	Urea	95,000 tons/yr	.....	Engineering	1962	Inventa	Lurgi/Uhde	Lurgi/Uhde
Korea Petroleum	Ilsan	Refinery	20,000 bbls	.....	Planning	.....	.....	.....	.....
MALAYA									
Shell of Singapore	Singapore, Malaya Peninsula	Refinery	.....	$13,300,000	Planning	.....	.....	.....	.....
Shell of Malaya	.....	Refinery	.....	$20,000,000	Planning	.....	.....	.....	.....
Standard Vacuum	.....	Refinery, Chemical Fertilizers	.....	.....	Planning	.....	.....	.....	.....
SINGAPORE									
Maruzen Oil, Toyo Manka Kaisha	Pasir Panjang	Refinery	20,000 bbls	.....	Under Constr	Dec 1961	.....	.....	.....
THAILAND									
Thai Defense Ministry	Bangkok	Refinery	5,000 bbls	$20,000,000	.....	.....	.....	Japanese Fuji	Japanese Fuji

Australasia

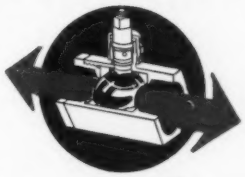
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRALIA									
Altona Petrochemical, Socony Mobil	Altona	Petrochemicals	.....	.....	Under Constr	.....	.....	.....	.....
Australian Oil Refining	Kurnell	Exp. Refinery:	.....	.....	.....	1961	UOP/ Kellogg	Kellogg/Staff	Staff
		Crude	45,000 bbls	.....	.....	.....		.....	.....
		Cat Cracker	18,000 bbls	.....	.....	.....		.....	.....
		Alkylation	3,400 bbls	.....	.....	.....		.....	.....
Australian Synthetic Rubber	Altona	Synthetic Rubber	.....	$10,000,000	Under Constr	Summer 1961	.....	Fluor	Fluor/Utah
Bitumen & Oil Refineries	Sydney	Diesel Unifiner	2,500 bbls	.....	Under Constr	.....	.....	UOP	Staff
		Crude	12,000 bbls	.....	Planning	.....	.....	Procon	Procon
CSRC Dow Pty	Altona	Styrene	.....	.....	Under Constr	July 1961	.....	.....	Bechtel/McDonald/Wimpey & Coy
Gas & Fuel	Melbourne	Catalytic Oil Gasification & Gas Reforming	10 MMcf	.....	Engineering	1962	Onia Gegi	H & G	H & G
Geelong Gas	Geelong	Refinery Gas Reforming	3 MMcf	.....	Engineering	1961	Onia Gegi	H & G	H & G
Imperial Chemical Industries of Australia & New Zealand	Botany	Polyethylene	25,000 tons/yr	$5,040,000	Under Constr	.....	.....	.....	.....
Shell Chemical	Clyde	Resins, Alkylates	.....	$22,000,000	Planning	.....	.....	.....	.....
		Cat Cracker	.....	$38,000,000	Under Constr	1963	.....	.....	.....
		Ethylene	.....	$22,400,000	Engineering	Early 1961	.....	Braun	Braun
Shell Oil	Newport	Oil Blending	.....	.....	.....	.....	.....	.....	.....
Shell Refining (Australia)	Clyde	Cat Cracker	24,000 bbls	.....	Planning	Late 1962	.....	.....	.....
	Geelong	Hydrodesulfurizer	11,000 bbls	.....	Planning	.....	.....	.....	.....
Standard Vacuum	Adelaide	Refinery	30,000 bbls	$30,000,000	Planning	1962	.....	.....	.....
	Altona	Petrochemicals (Ethylene & Butadiene)	20,000 tons/yr	$28,000,000	Under Constr	Spring 1961	.....	Fluor	Fluor/Utah
Union Carbide	Melbourne	Polyethylene	15,000,000 lbs/yr	.....	Planning	1961	.....	.....	.....
PHILIPPINE ISLANDS									
Filoil Refining	Luzon	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
Shell (Philippines)	Manila	Refinery	.....	.....	Planning	.....	.....	.....	.....
Standard Vacuum	Bataan	Refinery	25,250 bbls	$35,000,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler

*First appearance in tabulation.

Boxscore Abbreviations

Atlantic—Atlantic Ref. Co.
Austin—The Austin Co.
Badger N. V.—Badger N. V., Netherlands
Badger Mfg.—Badger Mfg. Co.
B & R—Brown & Root, Inc.
BASF—Badische Anilin & Sod. Fab.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C F Braun Co.
Calif. Res.—California Research Corp.
Canadian Badger—Canadian Badger Company Limited
Canadian Bechtel—Canadian Bechtel Limited
Catalytic—Catalytic Construction Co.
Chemico—Chemical Construction Co.
Chiyoda—Chiyoda Chemical Engineering & Construction Co.
CJB—Constructors John Brown, Ltd.
CTIP—Compagnia Technica Industria Petroli
Dresser—Dresser Engineering Corp.
Ehrhart—Ehrhart & Associates, Inc.
Esso—Esso Research and Engineering Co.
Ferguson—H. K. Ferguson Co.
Fluor—Fluor Corp.
Food—Food Machinery & Chem. Corp.
Foster Wheeler—Foster Wheeler Corp.
Girdler—The Girdler Corp.
H & G—Humphrey & Glasgow
Hudson—Hudson Engineering Corp.
Hydrocarbon—Hydrocarbon Research, Inc.
ICI—Imperial Chemicals, Inc.
JGC—Japan Gasoline Co.
Kellogg—The M. W. Kellogg Co.
Kidde Constr.—Walter Kidde Constructors, Inc.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Koppers—Koppers Co., Inc.
Fried. Krupp—Fried. Krupp Industriebau
Leonard—Leonard Construction Co.
Litwin—Litwin Engineering Co.
Lummus—The Lummus Co.
Lurgi—Lurgi G. m. b. H.
Macco—Macco Corp.
McKee—Arthur G. McKee Co.
MHW—McKee-Head Wrightson, Ltd.
Nofsinger—The C. W. Nofsinger Co.
Olsen—O. L. Olsen Co.
Parsons—The Ralph M. Parsons Co.
Pona—Pona Engineers, Inc.
Power Gas—Power Gas Corp., Ltd.
Pritchard—J. F. Pritchard Co.
Procon—Procon, Inc.
Quaker—Quaker Valley Constructors
S&W—Stone & Webster Engineering Corp., Chemical Division
S&W Ltd.—Stone & Webster England, Ltd.
SBA—Soc. Belge de L'Azote et des Produits Chimique du Marly
SD—Scientific Design
SFST—Societe Francais des Services Techniques
Soc. Chimique—Societe Chimique de la Grande Pareisse
Stearns-Roger—Stearns-Roger Mfg. Co.
Sumner Sollitt—Sumner Sollit Co.
Sweco—Southwestern Engineering Co.
Tellepsen—Tellepsen Petro-Chem Constructors
Treco—Refinery Engineering Co.
Uhde—Friedrich Uhde, G. m. b. H.
UOP—Universal Oil Products Co.
Vulcan—Vulcan Cincinnati, Inc.

A Significant Announcement to
the Refinery and Petrochemical Industries



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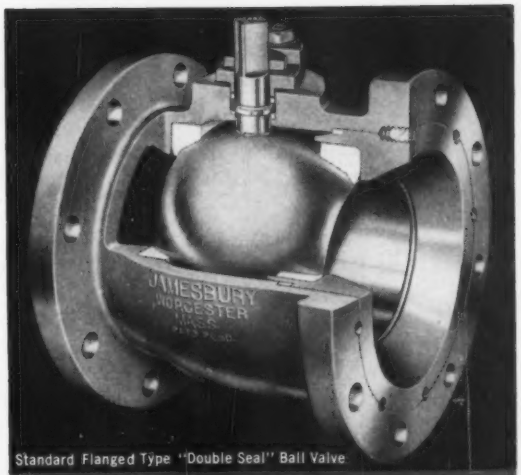
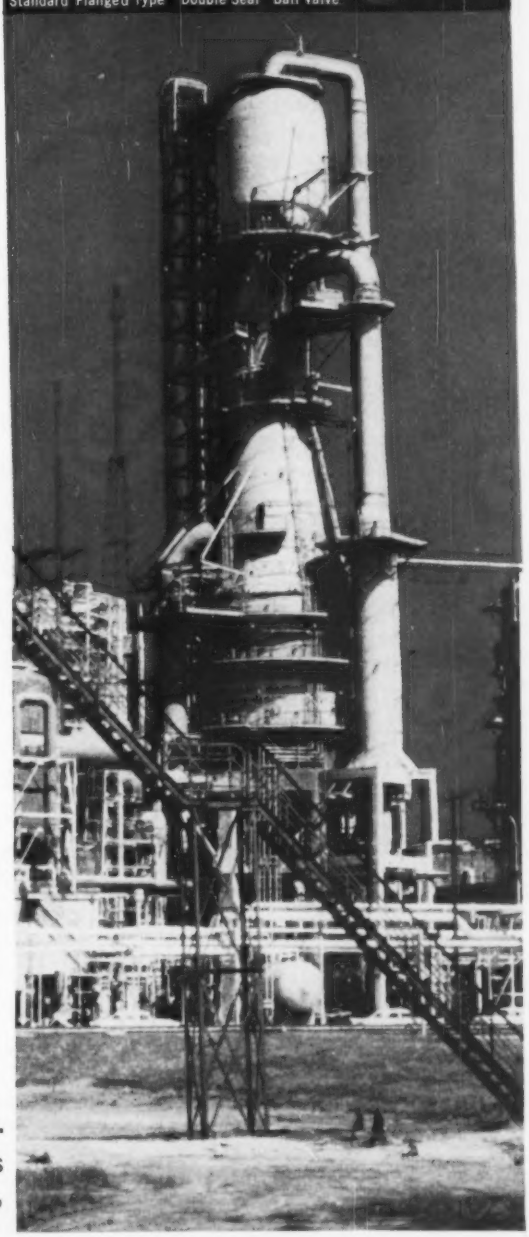
"Double-Seal"™
TYPE DZ
FIRE*SAFE†™
BALL VALVES*



Standard Flanged Type "Double Seal" Ball Valve



Available for application in a wide range of installations in the heart of the refinery processing areas and in petrochemical and natural gasoline processing services.

Proved in long-term pre-testing and in full scale processing installations, the Jamesbury "Double-Seal" FIRE SAFE Ball Valve brings the advantages of full flow, quarter-turn positive shut-off, low torque and no lubrication to "the heart of the process" in these industries.

Complete size range and materials data available on request.

Write for Jamesbury Refinery Brochure for further details.

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LPG Sales Close to 10 Billion Gallons

The 1960 picture shows an increase of 10.5 percent over 1959

IN 1960 LPG SALES continued to rise with an apparent increase of 941 million gallons which sent total sales to an estimated 9,860,000,000 gallons. This is 10.5 percent over 1959. While not as spectacular as the 19.5 percent gain of 1959 over 1958, it is enviable when compared with most other industries in 1960. (See Figure 1, Page 227.)

Domestic and Commercial—Sales were up an estimated 393 million gallons or 10 percent above 1959 to 4,328,000,000 gallons. Although this is a substantial gain over 1959, it falls short of the 19.5 percent increase of 1959 over 1958. Again this year, domestic and commercial sales kept pace with the total industry growth.

Motor Fuel—The sale of LPG for motor fuel increased an estimated 6 percent to a total of 943 million gallons.

Industrial and Miscellaneous—Portions of this category decreased as the result of natural gas expansion while others exhibited off-setting gains. The estimated total sales were about the same as in 1959—871 million gallons.

Gas Manufacturing—The sale of LPG for gas manufacturing continued to decline by about 25 percent to an estimated total of 137 million gallons.

Chemical Manufacturing—The manufacture of chemicals consumed an estimated total of 3,031,000,000 gallons of LPG which is an increase of 20 percent over 1959. This category exhibited the greatest growth in the industry this year. (See Figure 2.)

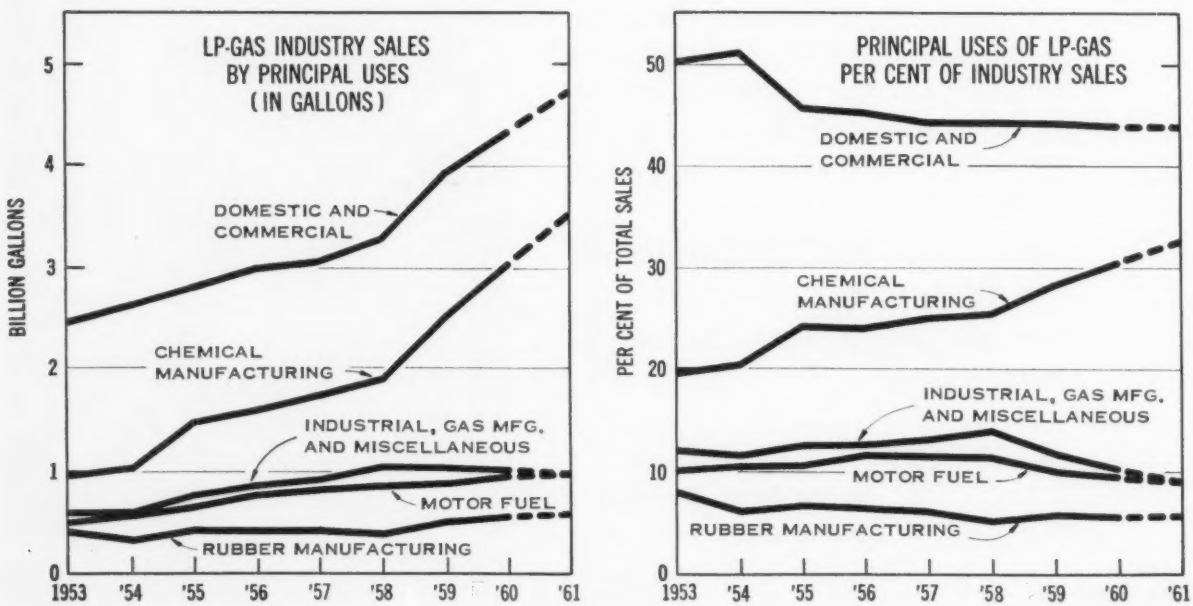
Rubber Components—The sale of LPG for use in the manufacture of synthetic rubber increased a modest 7 percent in view of the spectacular increase of 38.2 percent of 1959 over 1958. The total sales in 1960 were approximately 550 million gallons.

LP-Gas Appliances—LPG appliance sales in 1960 fell short of the 1959 sales volume, as did gas appliances in general. The decrease reflected a general tightening of consumer buying and fewer new housing starts.

Supply—LPG production in 1960 kept pace with the increased demand through expansion of production facilities (including new plants) and better recovery from existing plants. New gasoline plants numbered 39, and nine plant expansions were completed and placed on stream in the United States in 1960 to increase the

FIGURE 2

CHEMICAL USE OF LP-GAS INCREASES AT GREATER RATE THAN DOMESTIC USE BOTH TRENDS ARE SHARPLY UPWARD



CONTINUING . . .

in '61

WARREN RESOURCES

OF PRODUCTION . . . OF TRANSPORTATION
. . . OF STORAGE . . . PLUS

WARREN EXPERIENCE

(AS A SPECIALIST IN ITS FIELD)

Your assurance of . . .

DEPENDABLE DELIVERIES OF
NATURAL GASOLINE

whatever the GRADE, whatever the VOLUME
WHEN, WHERE and the WAY you want it.

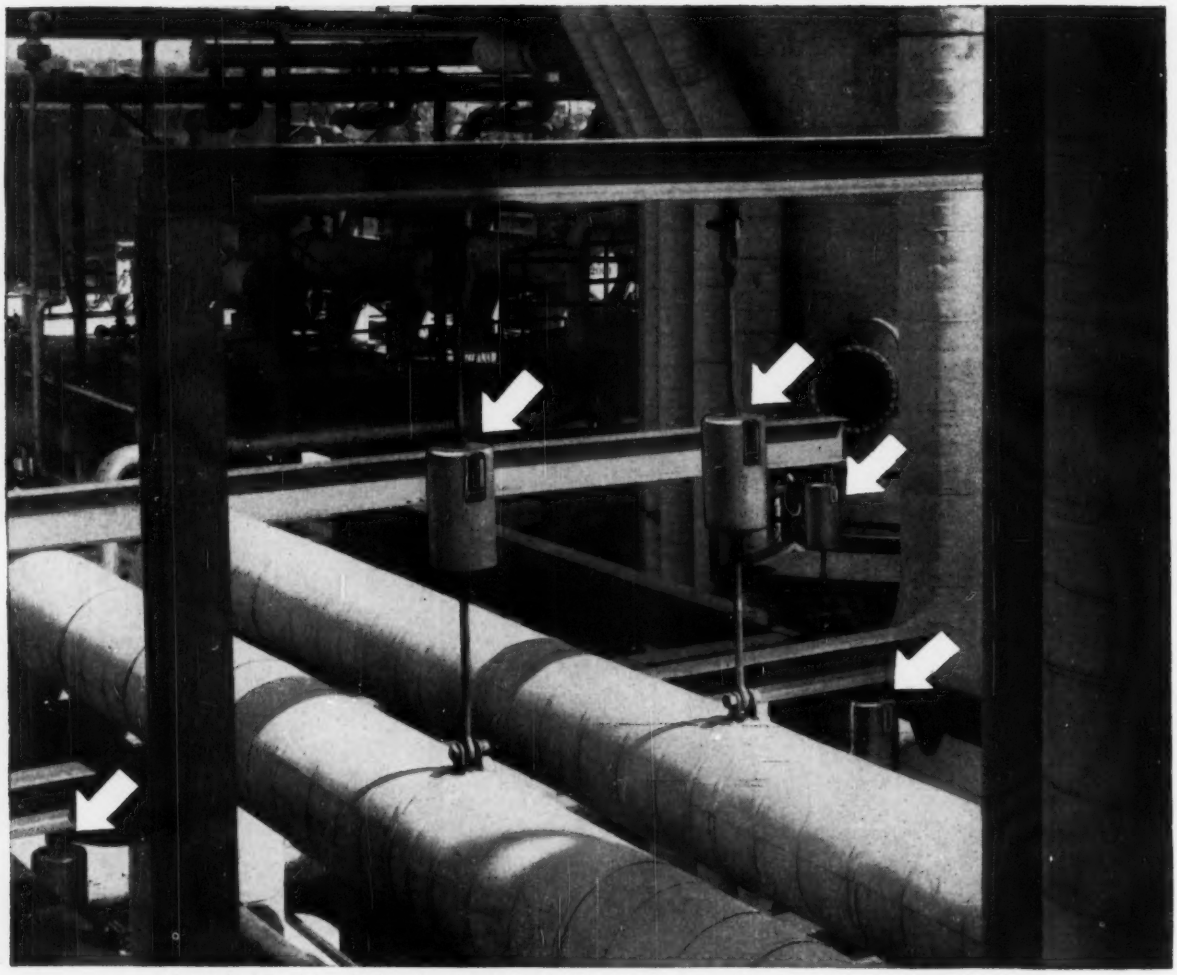
WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA

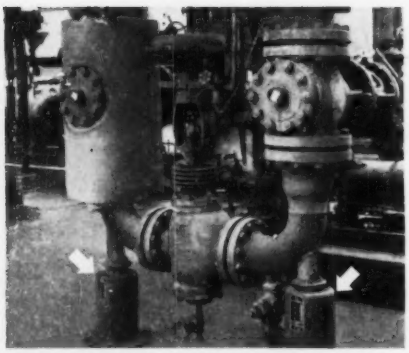
EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.

QUALITY • QUANTITY • SERVICE



Heater feed line (r.) and return line (l.) at Sinclair Refinery show Grinnell Variable Spring Hangers at work.

Grinnell Hangers support high-temperature pipe lines at Sinclair Refinery



Grinnell Variable Spring Hangers support bottom lines on vacuum still operating at 750°F.

Hot news: Grinnell variable Spring Hangers support pipe lines at Sinclair Refining Company's Marcus Hook, Pa. plant, that operate at temperatures *above 500°F.* Yet these flexible hangers easily accommodate thermal movement in the pipe lines!

Where reactive forces at terminal points must be kept within specified limits, *Grinnell Constant Support Hangers* are recommended. Where pipe lines are subject to vertical movement and restrictive conditions do not require the use of a constant support type, *Grinnell Variable Spring Hangers* are recommended. Where abnormal horizontal movement or vibration in pipe lines must be prevented, *Grinnell Sway Braces* are recommended.

Grinnell maintains a staff of trained technicians . . . provides highly skilled advice and assistance right from the design stage . . . offers experienced field engineering service. Call Grinnell Company, 277 West Exchange Street, Providence 1, R. I.

GRINNELL AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Pipe Fittings, Valves, Pipe Hangers, Prefabricated Piping, Unit Heaters and Piping Specialties • Branch Warehouses and Distributors from Coast to Coast

daily production capacity by 3,200,000 gallons.

The continuing increased use of butane in chemical feedstocks and for gasoline blending indicates that less and less butane will be available to the domestic market in the future. This, of course, means that there will be increased activity by distributors and dealers in converting from butane to propane facilities, particularly in the South and Southeast, to serve the domestic market.

There is continued activity in increasing underground storage capacity in both mined and washed caverns. The total underground storage capacity for natural gas liquids in the United States is about 2,282,000,000 gallons. This is an increase of almost 17 percent over 1959. The emphasis appears to be on mined caverns near heavy marketing areas where storage caverns cannot be washed due to lack of usable salt formations.

Transportation—Significant advances in the transportation of LPG were made in 1960 to keep pace with industry growth. It is apparent that lower transportation costs resulting from these developments have been instrumental in sustaining the growth of the industry.

An important factor in LPG transportation developments is the trend to larger capacity highway transports, both in "bobtail" delivery units and "over-the-road" units. Transports of over 10,000-gallon capacity, and 2,500 gallons and larger "bobtails" are gaining wide acceptance. In connection with these larger capacity units, the industry is developing high speed equipment and techniques for loading and unloading. Five hundred gallons per minute transport loading rate became a reality in 1960.

There is also continued interest in the use of positive displacement meters to provide rapid, accurate measurement of products.

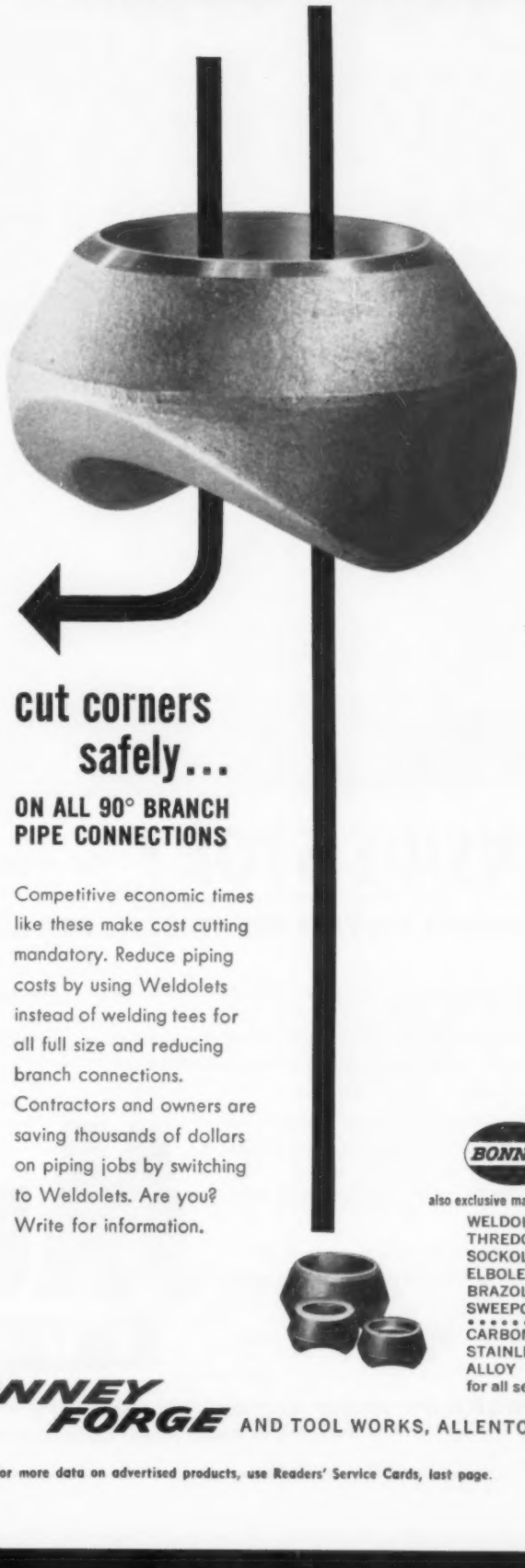
A new development in LPG transportation is the "piggyback" movement which has been approved by regulatory bodies. Whether or not this will become an important factor in LPG transportation remains to be seen.

Safety Developments—NFPA Pamphlet 58 was again revised to keep pace with new and improved equipment and safe operating techniques. Greatly increased efforts are being made at all levels of the industry to acquaint personnel with safe handling practice and techniques—particularly the proper methods of handling emergency situations.

Outlook—The LPG industry has made great strides practically each year, but the market is far from saturated. The growth rate may well level off some, but there is no indication of any rapid decline in growth rates for the industry.

As competition becomes more keen,

BONNEY WELDOLETS



cut corners safely...

ON ALL 90° BRANCH PIPE CONNECTIONS

Competitive economic times like these make cost cutting mandatory. Reduce piping costs by using Weldolets instead of welding tees for all full size and reducing branch connections. Contractors and owners are saving thousands of dollars on piping jobs by switching to Weldolets. Are you? Write for information.

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BONNEY FORGE AND TOOL WORKS, ALLENTOWN, PA.

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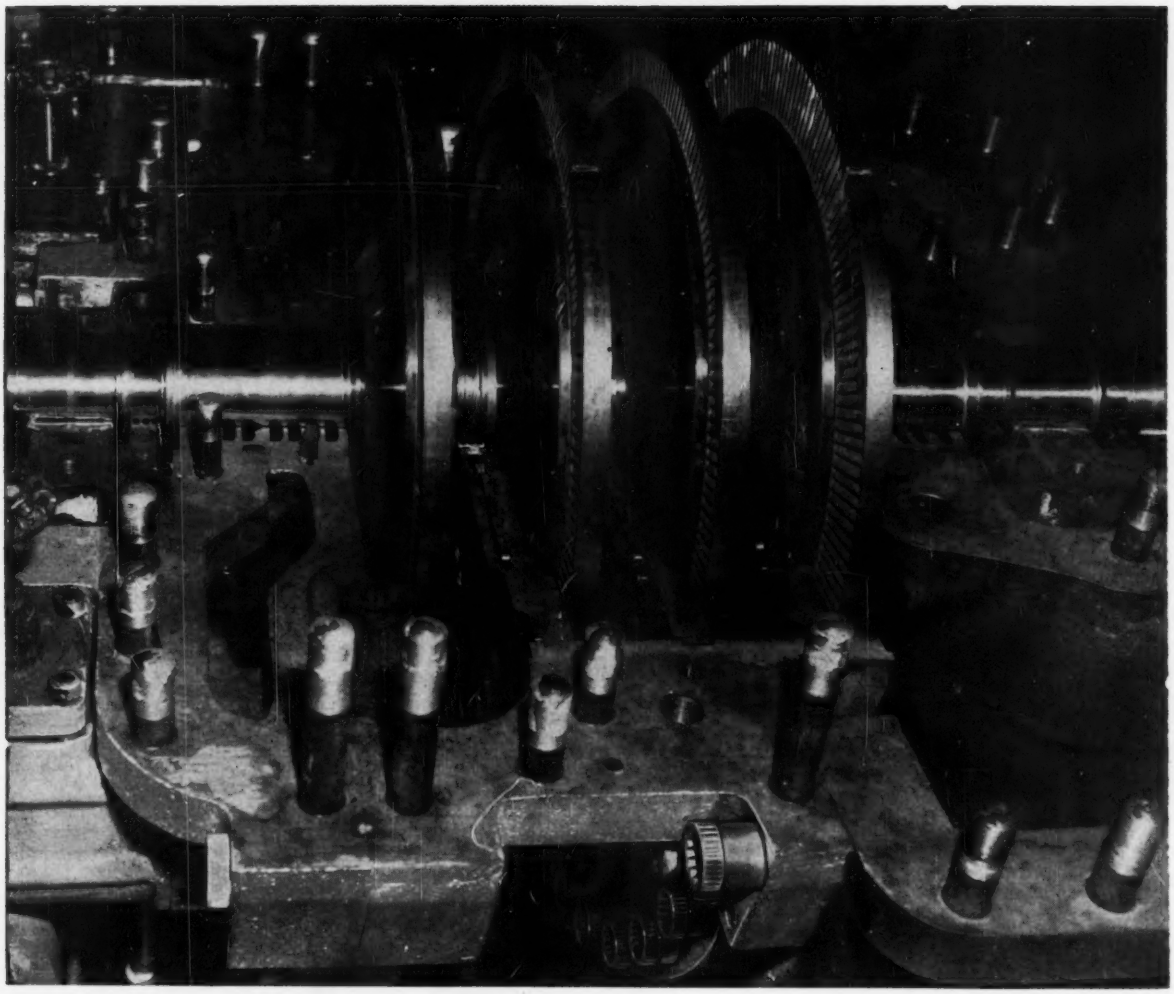

THE INSIDE STORY OF A MURRAY HIGH SPEED COMPRESSOR

DRIVE TURBINE REVEALS THE REASONS FOR MURRAY'S UNIVERSAL ACCEPTANCE

A look at MURRAY'S rugged construction from the inside shows the husky shaft and heavy accurately formed discs with generous sized hubs designed to withstand the axial and radial stresses imposed by this type of service.

Large-dimension disc rims receive the specially contoured stainless steel blades with the Murray integral shroud. This insures smooth steam passages with maximum strength.

Short bearing spans insure smooth operation and eliminate the hazard of operating in critical speeds.

A look at the heavy flanges and husky bolting in the actual unretouched shop photo shown above bears out the extreme ruggedness that typifies every feature of Murray construction.

Our nearest representative will gladly help you solve your high speed compressor drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA
Builders of Steam Power Equipment for Nearly a Century

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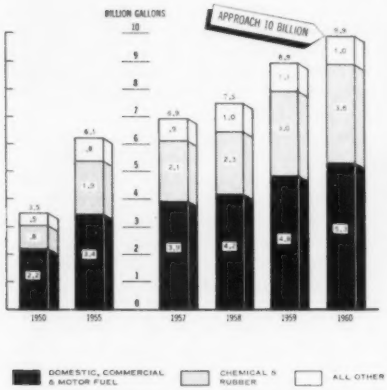
both within the LPG industry and with other fuel industries, more and more stress is necessarily placed on operational efficiency and improved management techniques. There is every indication

FIGURE 1
LP-GAS INDUSTRY SALES



that equipment, operating methods and the individual ingenuity will keep pace and make it possible for the industry to continue to exhibit good growth rates in a highly competitive atmosphere.

Gain in 1960 Demand Less Than Expected, Says Porter

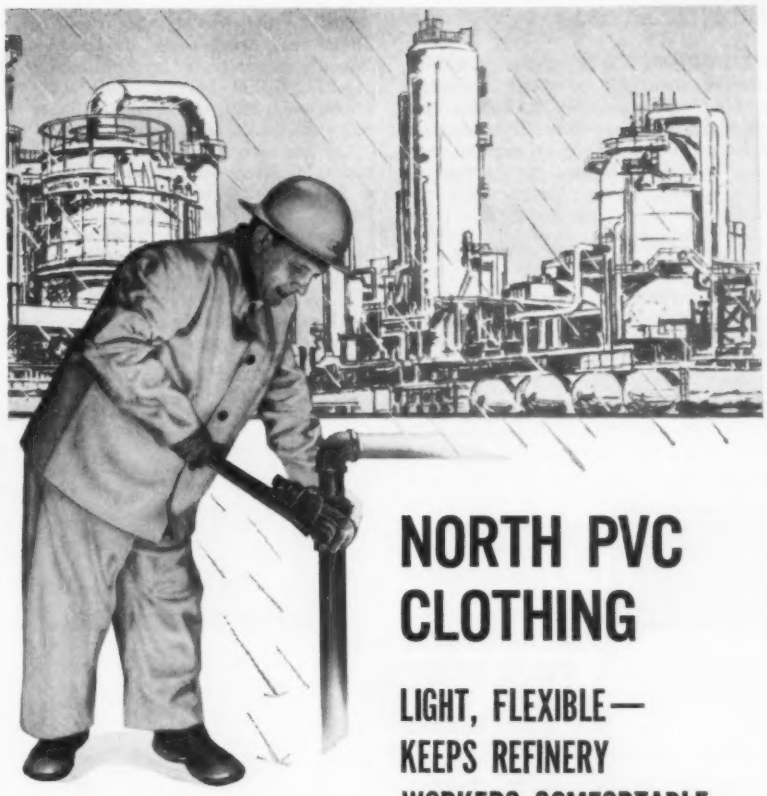
Although demand for petroleum products showed a further increase during 1960, the rate of gain was considerably less than the year before and substantially smaller than had been anticipated generally at the start of 1960. This was announced by Frank M. Porter, president of the American Petroleum Institute, in his year-end review of oil industry operations.

He estimated that domestic demand for petroleum products as a whole approximated 3,532,000,000 barrels, compared with 3,450,000,000 barrels in 1959. On a daily average basis, this works out to 9,651,000 barrels and represents a year-to-year gain of only 2.1 percent, as contrasted with an increase of more than 4 percent experienced in 1959.

With exports showing a further slight drop to less than 75 million barrels, total demand (domestic and exports) for the year is placed at 3,607,000,000 barrels, or just 2 percent above the 1959 figure.

Turning to the major refined products, Porter noted that demand for gasoline was especially disappointing, with indicated consumption for the year running only 2 percent higher than in 1959. He attributed much of the blame for this to burdensome taxes on motor fuel, which have greatly stimulated the growth of economy-type cars.

On the supply side of the picture, domestic crude oil production for 1960 is estimated at about 2,568,000,000 barrels, or some 6 million barrels less than



NORTH PVC CLOTHING

LIGHT, FLEXIBLE— KEEPS REFINERY WORKERS COMFORTABLE

When clouds gather, and rain or snow falls, outdoor refinery workers don North PVC Wet-Weather Clothing by Jomac.

They stay dry because the shielded and electronically welded seams won't pull apart, the welded PVC buttons won't pull off, and the material is absolutely waterproof. They stay safe because North PVC clothing resists most chemicals, oils and greases, is safety yellow for maximum visibility. They stay comfortable because set-in sleeve design and generous cut provide complete freedom of movement.

Insist on North PVC gloves for maximum hand protection. They offer better fit, greater dexterity, more comfort, and superior safety in handling most chemicals, oils and greases.

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Philadelphia 38, Pa.

In Canada: James North Canada Company Ltd., Simcoe, Ont.
"JOMAC Sells Quality . . . and Quality Sells JOMAC!"

For more data on advertised products, use Readers' Service Cards, last page.

in 1959. Production of natural gas liquids, however, increased by about 23 million barrels to approximately 344 million barrels, bringing total domestic production of liquid hydrocarbons to slightly more than 2.9 billion barrels, an increase of 17 million barrels over the previous year. Total imports of crude and refined products are estimated at approximately 669 million barrels or about 20 million barrels more than in 1959.

The industry's year-end inventory situation presented a mixed picture. With crude supplies holding fairly constant and with refinery operations running at relatively high levels throughout most of the year, crude stocks dropped nearly 25 million barrels to an estimated total of 232,500,000 barrels. This was the lowest year-end crude stock figure in more than a decade.

On the other hand, gasoline inventories (finished and unfinished) showed a further increase of over 6 million barrels, to an estimated total of over 194 million barrels. Kerosine stocks were up substantially, due primarily to inclusion of commercial jet fuel.

However, estimated year-end stocks of distillate and residual fuel oils were lower than a year earlier. This was particularly true of residual fuel oil inventories, which declined more than 9 million to approximately 44 million barrels.

Refractories that last longer

- Extensive Line of Plastic and Castable Refractories to *Exactly* Meet Any Service Condition
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- Installation by Highly-Skilled Company Representatives Makes Certain Engineering Recommendations are Followed

Unified Responsiblity Assures You the Finest Job Possible

Send for "The Plibrico Story" for Details of this Integrated Service

Representatives: 97 U.S. Cities in 38 States (Check your classified directory) and in 37 Foreign Countries

Plibrico company

Since 1914—First in Plastic Refractories

1800 N. Kingsbury Street
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Incinerators "Packaged" or Custom Built

September Crude Output Tops August by 31,000 bpd

Production of crude petroleum in the United States averaged 6,971,000 bpd in September, an increase of 31,000 bpd over the August average of 6,940,000 bpd, reports the Bureau of Mines, United States Department of the Interior. Crude production in the first nine months of 1960 averaged 42,000 bpd less than in the same period of 1959.

The indicated demand for all crude oil in September decreased 145,000 bpd, comprising a decrease of 156,000 barrels for domestic crude and an increase of 11,000 bpd for foreign crude. Total crude stocks, domestic and foreign, amounted to 231,966,000 barrels on September 30, compared with 234,091,000 barrels at the end of August, a decrease of 2,125,000 barrels. This was the lowest level of end-of-month crude stocks since September 30, 1948, when a figure of 228,401,000 barrels was reported.

Total crude runs to stills in September averaged 8,100,000 bpd. Comparing runs for the first nine months of 1960 and 1959, total runs increased 91,000 bpd, including a 17,000 bpd increase in runs of domestic crude and a 74,000 per day increase in foreign crude runs.

Stocks of refined products at the end of September amounted to 549,018,000 barrels, an increase of 14,057,000 barrels during the month and 750,000 barrels below the level of stocks reported for September 30, 1959. Total demand for all oils in September was 9,206,000 bpd, including domestic demand amounting to 9,019,000 bpd and exports of 187,000 bpd. Compared with 1959, total demand in the first nine months of 1960 was up 2.0 percent and domestic demand up 2.2 percent.

The total crude oil capacity of operating refineries in September was 9,705,000 bpd, indicating an operating ratio of 83.5 percent, compared with 85.2 percent in August.

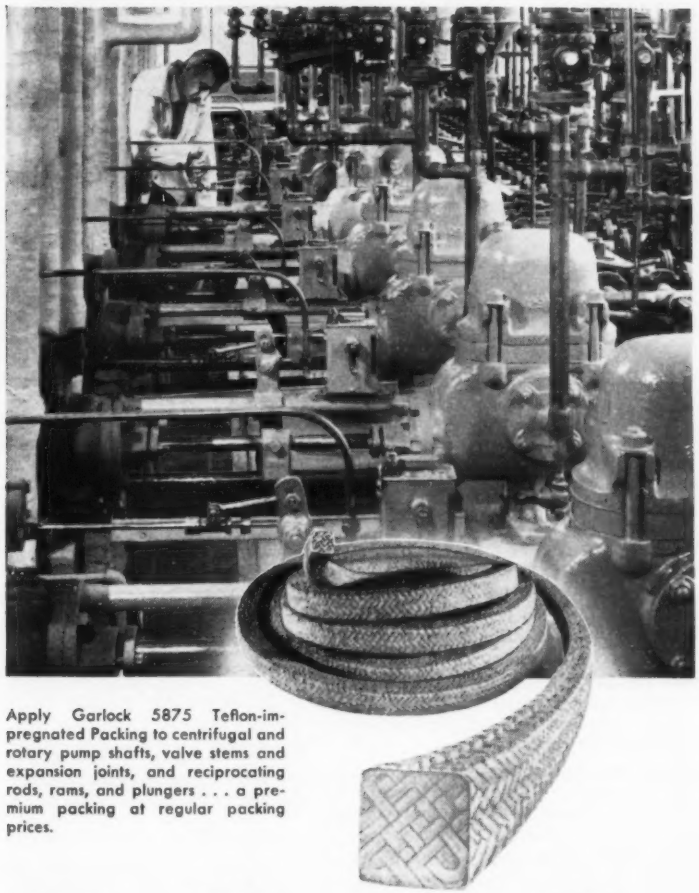
Texaco Head Sees Good Year in Store for Petroleum

Predictions that 1961 will be a good year for the petroleum industry were made recently by Augustus C. Long, board chairman of Texaco, Inc., at a meeting of the New York Society of Security Analysts. Long forecast that United States demand for petroleum and its products next year will rise 2 to 3 percent and foreign demand 7 percent.

"At the close of 1960 the industry is in better shape, both as to total inventories and as to prices, than last year," he said. "Because of this fact and because our business is more resistant to downturns in the economy, we feel that we will enter the new year with better prospects than a year ago."

Long said Texaco's capital and exploratory expenditures for 1960 will total

ENGINEERED TEFLON PRODUCTS
for Petroleum Refining



Apply Garlock 5875 Teflon-impregnated Packing to centrifugal and rotary pump shafts, valve stems and expansion joints, and reciprocating rods, rams, and plungers . . . a premium packing at regular packing prices.

NOW—YOU CAN BUY GARLOCK TEFLON* PUMP PACKING AT REGULAR PACKING PRICES!

Through an improved manufacturing technique, Garlock offers a Teflon-impregnated LATTICE BRAID Packing at a reduction of approximately 40% over the price of similar competitive packing. Designated Garlock 5875, this packing can be purchased at prices comparable to regular packing.

Enjoy premium benefits without a premium price. Garlock 5875 offers a high Teflon content—more than 30% by actual weight—for greater protection, reduced wear. In temperatures from −90° F to +500° F, Teflon-impregnated LATTICE BRAID Packing is recommended for use against moderately destructive and corrosive mineral acids and caustics. For more destructive and corrosive applications, Garlock 5888 Teflon-treated fiber packing is recommended. Teflon, too, is as "frictionless" a material as you will find; this greatly reduces wear to the packing itself, and to any moving parts that it contacts during normal operation.

Specialized construction provides longer life, less maintenance. Garlock 5875 Packing is made from Teflon-impregnated white asbestos yarn, woven in the superior LATTICE BRAID construction. Here, each strand of treated yarn is intertwined at a 45° angle through the packing body. This completely integrates the structure for greater strength and, unlike ordinary square or round braid, eliminates individual *layers* of yarn—layers that, once worn through, destroy the usefulness of the packing. Without a layer or single outer braid to wear through, LATTICE BRAID remains unified without disintegrating far beyond the limits of other packings.

Enjoy fast delivery from warehouse stock. Garlock 5875 Packing is immediately available in sizes from ¼" through ⅝" in either spool or reel form to meet your specific needs; also available on order in ring form in these sizes. Specify now from your local Garlock representative at the nearest of the 26

GARLOCK

Garlock sales offices and warehouses throughout the U.S. and Canada. Or, for more information, write for Catalog AD-185, Garlock Inc., Palmyra, New York.

Canadian Div.: Garlock of Canada Ltd.
Plastics Div.: United States Gasket Company

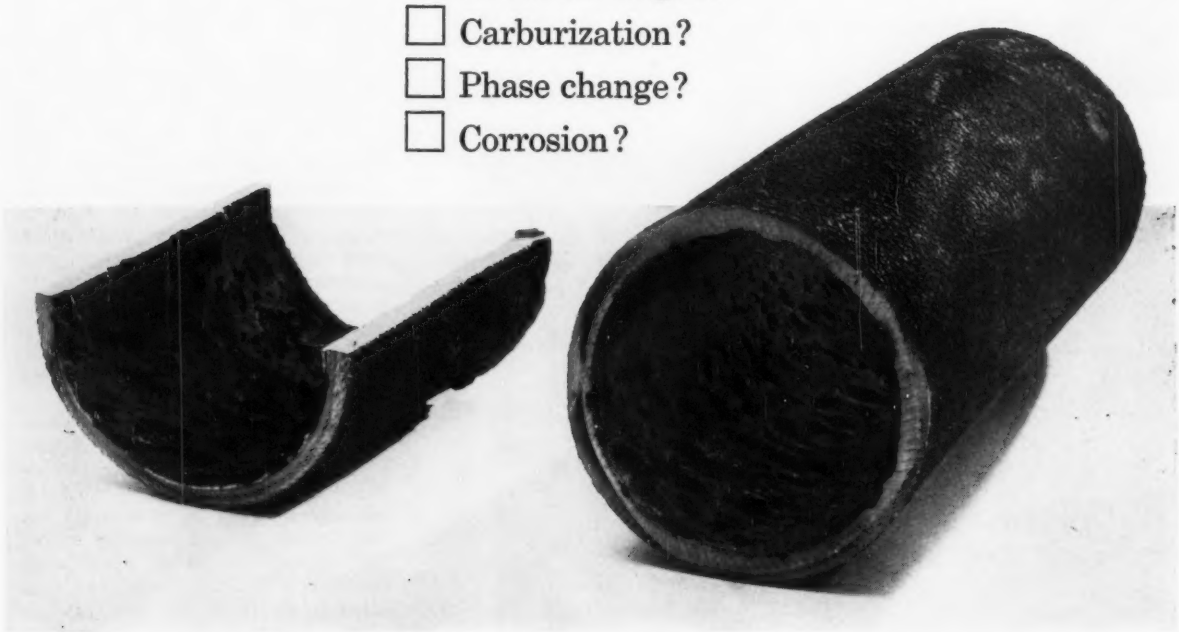
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark for TFE Fluorocarbon Resin

For more data on advertised products, use Readers' Service Cards, last page.

Which was the Failure Mechanism here?

- ☐ Creep?
- ☐ Oxidation?
- ☐ Thermal fatigue?
- ☐ Carburization?
- ☐ Phase change?
- ☐ Corrosion?



The selection of materials and the design of castings for high-temperature service (1200-2300° F) in refineries and chemical plants have been dictated by concentration on corrosion problems. True, corrosion problems are accelerated by the application of heat.

But corrosion did not produce the failure shown above. This failure is the result of carburization. And carburization is one of *five primary* causes of high-temperature equipment failure: creep, oxidation, thermal fatigue, carburization and phase change.

To insure longer service life from his high-temperature equipment, the corrosion engineer must concern himself with an analysis of these mechanisms as related to his specific operating conditions.

In terms of refinery and chemical plant operations, the causes and failure forms of these mechanisms are as follows:

Creep failures are caused by temperature and stress and are speeded up by temperature cycles in the operations. Creep failures manifest themselves as dimensional distortions.

Oxidation is produced by the atmosphere used in the operation and the temperature. Scaling is a characteristic of this failure.

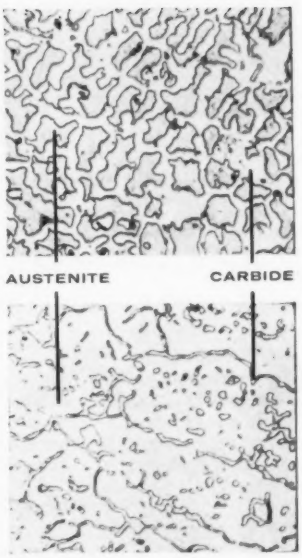
Thermal Fatigue arises from cyclical heating and cooling and thermal gradients across the metal section. The failure evidences itself as cracking and distortion.

Carburization, the absorption of carbon by the metal, occurs at high temperatures in carbonaceous atmospheres. The composition change produces lower hot strength.

Phase Changes, such as sigma formation, impair the properties of the material. Phase changes are evidenced by brittleness at room temperatures.

The mechanisms are interrelated and may jointly cause failure of the equipment. However, certain operating conditions at high temperatures lead to failures by one mechanism or another.

Subsequent advertisements in this series will treat each of these mechanisms in more detail and illustrate what Electro-Alloys is doing to minimize their effects.



Photomicrograph (250x) contrasts inside (top) and outside diameters of material after carburization failure.

AMERICAN Brake Shoe COMPANY **ELECTRO-ALLOYS DIVISION • Elyria, Ohio**

some $500 million and are expected to approximate this level in 1961. Over the next five years, the company expects to spend about $3 billion for such purposes, excluding equity in affiliated companies, he stated.

The Texaco chairman described the mandatory oil imports program as "arbitrary and inflexible." "By giving import allocations to companies with no foreign investment or historical pattern of imports," he said, "the program discriminates against companies which risked funds to develop oil resources abroad."

Long suggested that a system of tariffs on imported oil—taxing current volume at one level and increases at much higher levels—would be far more desirable. Under this proposal, the refiner receiving an import quota would be required to process the imported crude in his own refinery.

Operable Capacity Forecast At 9,948,850 bpd for '61

The refining industry expects to have a daily operable capacity of 9,922,350 barrels as of the end of 1960. The figure is expected to reach 9,948,850 bpd by September 30, 1961.

These totals, which were presented by the American Petroleum Institute Bulletin No. 59, are exclusive of 64,000-bpd capacity which on September 30, 1960, was shut down in need of major repairs, but include 474,000 bpd capacity which, while operable, was also shut down as of that date.

For the country as a whole, the September 30, 1960, figures include about 106,050 bpd which is represented by crude oil charged direct to cracking units.

Petroleum Demands to Hit High Point in First Quarter

Total petroleum demands will hit a seasonal high of 10,900,000 bpd in the January-March period, but U.S. crude oil output won't change much unless oil imports are reduced. This was the picture presented in the December "Supply and Demand Outlook" of the Independent Petroleum Association of America.

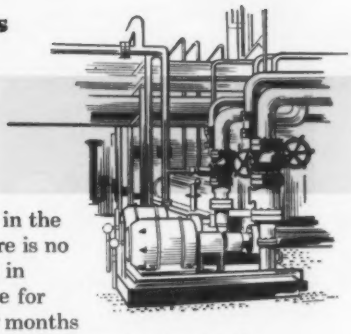
The IPAA forecast for the 1961 first quarter assumes normal temperatures and is only 100,000 bpd or 1 percent higher than the same period of 1960 when weather was colder than normal. Effect of weather on oil demands during the heating season also was dramatized in the past three months, September through November. Total demand averaging 9,490,000 daily was only 39,000 barrels higher than in the same 1960 period largely because October and November were "warmer than normal."

"As a result," said IPAA, "demand for heating oils during the September-November period averaged about 5 percent less

Positive Proof...

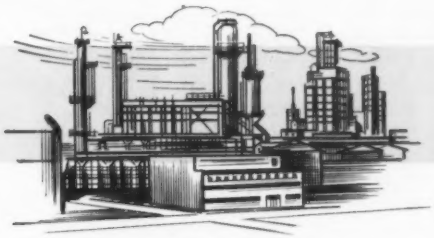
The John Crane® Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



✓ from an Arkansas Refining Plant

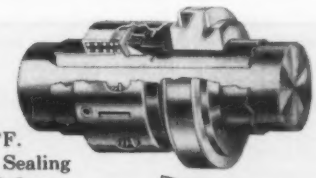
When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.



✓ from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.



CONDENSED SPECIFICATIONS

Recommended services: all industrial chemicals, corrosives, liquids or gases. Temperatures: –120°F. to +500°F. Pressures: up to 750 psi. Construction: Sealing members of chemically inert DuPont Teflon, metallurgy best suited to service requirements.

Send us your problems. Request Bulletin S-205-2.

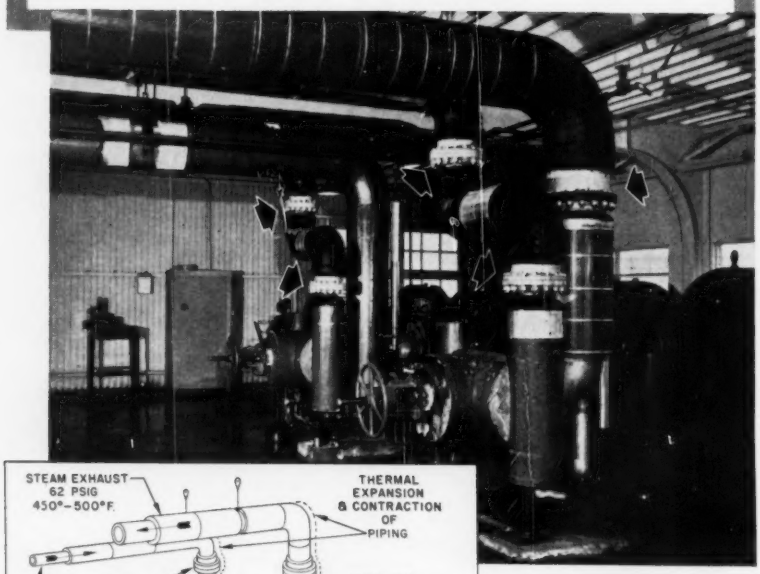
Crane Packing Company, 6420 Oakton Street, Morton Grove, Illinois, (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

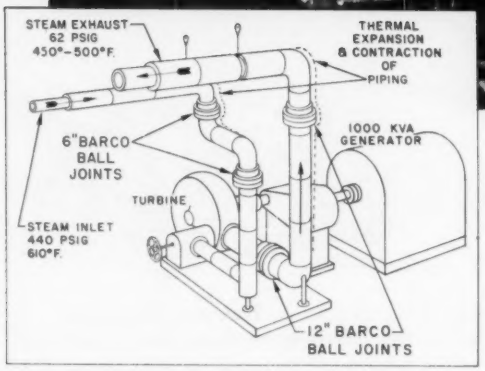
John Crane — MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

CRANE PACKING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

Barco Saves Time, Money on Steam Turbine Piping—





BARCO

BALL JOINTS

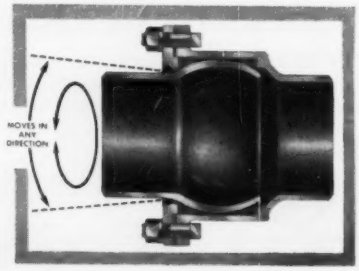
1. Handle Expansion **2. Relieve Torsion** **3. No "End Thrust"**

PROBLEM For the turbine installation shown above, layout of the piping presented involved pipe stress calculations to allow for thermal expansion and to eliminate torsional effects. In addition, a considerable expenditure had to be allocated to cover construction of heavy pipe anchoring and to control expansion "end thrust". *Could engineers find a better way to solve these problems? THEY DID! . . . and they saved about $2,000.00.*

ANSWER Instructions were simple: (A) "Install Barco Ball Joints —two* in each riser near turbine." (B) "Cut loose anchor stops; allow piping to move freely in all directions." (C) "Use spring hanger supports for the long horizontal runs of piping."

***Standard Type N for exhaust; High Temperature Type HT Joints for steam inlet lines.**

Barco Ball Joints provide convenient points of flexibility in piping to allow for both expansion and twisting. They develop NO "END THRUST"; expensive anchoring is not required. Easy to engineer. Rugged all-steel construction with no thin wall sections, no critical points of fatigue, no rubber seals. No lubrication required. Sizes and styles to meet your requirements. *Ask for new Bulletin 31B, "Thermal Expansion and Contraction in Piping."*



BARCO MANUFACTURING CO.

5428 Hough Street, Barrington, Illinois

In Canada: The Holden Co., Ltd., Montreal

Happenings . . .

than during the same months last year."

IPAA said inventories of refined products November 30 totalled 584 million barrels, slightly higher than at the same time last year.

Assuming downward adjustment in product inventories and first quarter demand of 10,900,000 bpd, IPAA said total new supply from U.S. crude oil and natural gas liquids production and imports totalling 10,200,000 bpd would be required in this period.

Natural gas liquid production in the first quarter is expected to be 990,000 bpd, but levels of controlled imports for this period haven't been announced. If imports are not reduced from levels of the last six months, market for domestic crude oil will average 7,175,000 bpd—up only slightly from estimated December output of 7,150,000.

"If imports are reduced as proposed by the Oil Import Administration," said IPAA, "domestic production would be increased accordingly."

World Rubber Consumption May Reach New High in '61

World rubber consumption, exclusive of Iron Curtain synthetic rubber, should reach a new high of 3,800,000 long tons in 1961, an increase of 1 percent above the 1960 record, J. W. Keener, president of The B. F. Goodrich Co., said in a year-end statement.

Rubber consumption in the United States in 1961 will be around 1,555,000 long tons, about the same as in 1960, Keener said. The rest of the free world will use approximately 1,800,000 long tons, an increase of 3 percent over 1960. Iron Curtain natural rubber imports account for the remainder of the 3,800,000 long-ton world estimate.

Synthetic rubber is expected to continue to capture a bigger share of the total rubber market, reaching 71 percent in the United States and more than 37 percent in the rest of the free world, said Keener. Total business activity will continue near current levels through most of the first half of 1961, but is expected to swing upward in the second half, Keener indicated. The USA gross national product will reach an all time high of $513 billion, $9 billion above 1960, he said.

Oil Industry Progressed In '60 Says Conoco Chief

Despite such adversities as oversupply and excess capacity, the oil industry made significant progress in 1960, especially during the last six months, according to L. F. McCollum, president of Continental Oil Co.

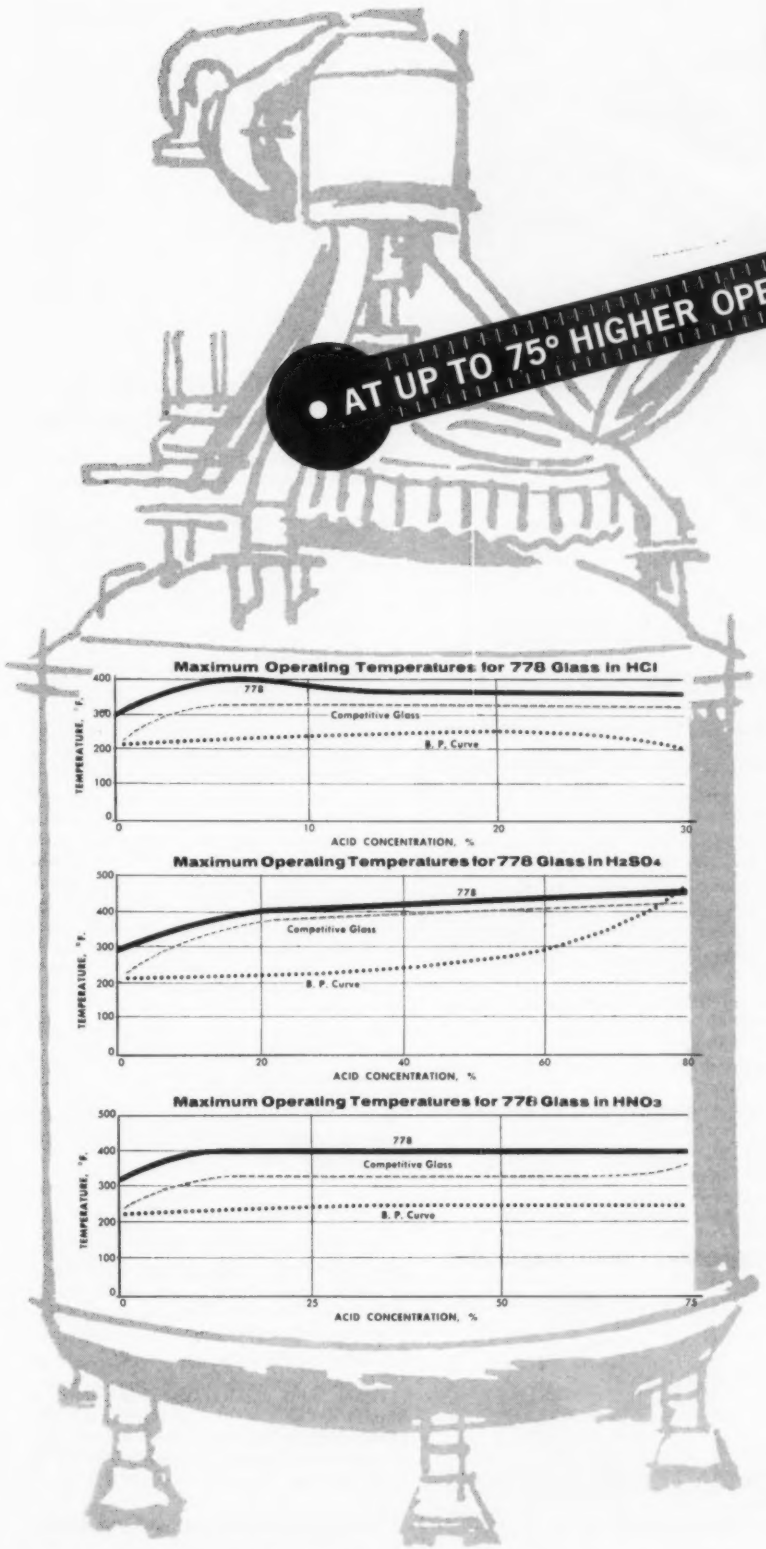
McCollum, in making his year-end statement, said:

"The refining segment of the industry

MORE ACID RESISTANT

● AT UP TO 75° HIGHER OPERATING TEMPERATURES

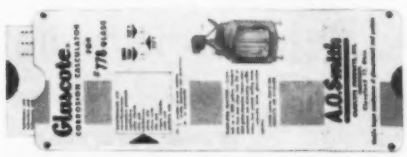
and now standard on all GLASCOTE process equipment



Take a good look into the Glascote reactor shown at the left — it contains proof that you can speed reaction time in vessels lined with sensational Glascote 778 . . . that you get a glass lining that extends acid resistance to 75° F higher operating temperature. And all this with no sacrifice in its ability to resist alkalies and thermal shock.

No wonder so many of our customers specified Glascote 778 . . . small wonder that we have this remarkable acid-resistant glass standard on all Glascote reactors, columns, storage tanks, rotary dryer-blenders, pipe and fittings. But keep in mind that this popular glass lining is just one of over 3000 formulations. Some may be even more effective for special requirements.

For your convenience we have prepared a special "resistance rule." It lists 150 chemicals and shows at a glance the ability of Glascote 778 to resist their corrosive attacks. Send for your rule today or see your Glascote representative.



Through research . . . a better way

A.O.Smith
CORPORATION

Subsidiary: GLASCOTE PRODUCTS, INC.
Cleveland 17, Ohio

World's largest manufacturer of glass-protected steel products

For more data on advertised products, use Readers' Service Cards, last page.

This Ampco Pipe has a ¾" wall, to handle sulphuric acid sludge in oil-company operation.

Sulphuric Acid Sludge No Problem

for major oil company,* in 1000-lb. transfer service

Its Ampco Pipe and Fittings resist corrosion

Ampco Pipe successfully handles problem liquids like these:

Boiling sulphuric acid (up to 50%)

Hot concentrated caustic solutions

Phosphoric and acetic acids

Phthalic anhydride

Phenols

Furfural

Brine

*Name upon request

Many other companies avoid corrosion shutdowns this same way.

Ampco Pipe is made from an exclusive aluminum-bronze alloy that . . .

(a) Resists many acids and caustics.

(b) Withstands the action of abrasive solids in suspension—resists cavitation-pitting.

(c) Has a Brinell hardness of 150 and tensiles up to 70,000 psi.

(d) Stands up under wrenches and hammers, without thread distortion and subsequent leakage.

(e) Has high velocity tolerance — flow rates of 18-20 fps.

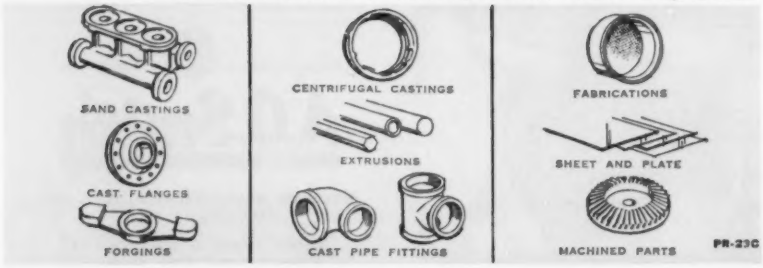
You can get Ampco Pipe in all standard sizes, many from stock. Fittings are available to 3000 psi; flanges, to 5000 psi.

Write us concerning *your* problem.

AMPCO METAL, INC.
Dept. 381A MILWAUKEE 1, WIS.
Huntington Park, Cal. • Garland, Texas

AMPCO®

THE METAL WITHOUT AN EQUAL



Happenings . . .

is also entitled to credit for some of the progress we have made. Many refiners have apparently come to realize the fallacy behind the "incremental barrel" profit theory, when that theory is put into practice in a period of oversupply. They have soundly resisted the temptation to run their plants at full capacity, regardless of whether any market exists for their output. As a consequence, it seems likely that 1960 refinery runs will exceed those of 1959 by only about 1 percent. With demand up 2 percent, this commendable exercise in self-restraint has brought about the much-needed reduction in product inventories. Inasmuch, however, as product stocks are still unduly high, all refiners may be well advised to continue sound economic practices."

Electronic Gas Blender Is On Stream at Wilshire Plant

The world's first automatic electronic gasoline blender has been placed on stream at the Wilshire Oil Co. of California refinery in Santa Fe Springs, Calif.

Electronic blending has been under development for several years by various oil companies throughout the world although Wilshire has succeeded in being the first oil company to go on stream with a completely electronic unit.

The advantages of an electronic system are greater formulation accuracy and ability to use longer signal transmission lines from the control console valves of the actual blending equipment. In addition, the resulting blend provides maximum customer benefits in that constant quality is always assured and further, the manufacturer is able to achieve maximum utilization of blending stock inventories.

The blend operator sets the blend formulation from push buttons at the console. The blend will proceed automatically until the desired quantity of blended gasoline is delivered at which time the electronc blender will shut off all valves and stop all pumps.

If the blender fails to deliver the correct quantity of a particular component, it will be instantly noted on the console by supervisory lights and by an audible alarm. After a short time, the blender will automatically shut down until the trouble has been corrected.

- Changing Times -

Air pollution will be the problem of a group formed by the American Society of Civil Engineers. The organization, called the Research Council on Air Resources, will approach the problem on an engineering basis.

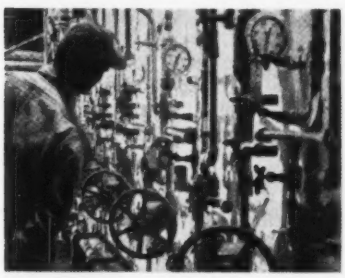
Giant fluid catalytic cracking unit at Standard Oil Co. of California's El Segundo refinery is controlled directly by a large-scale digital computer 450 miles away in San Francisco.

Refining, producing and marketing

What the RMC system of recalibration means to you

Sometimes it is necessary to recalibrate industrial thermometers due to severe shock from rough handling, or to calibrate for extreme accuracy at any point on the scale for special work range.

Various recalibration systems are employed in the different makes of ordinary bimetal thermometers. Most all of them will achieve the desired recalibration, but a number of undesirable things may also result. In some, all semblance of air-tight seal is automatically destroyed in removal of the dial glass. In others, the critical pointer shaft may become bent or twisted. And still others use a mechanism incapable of holding the new setting for any length of time. *None of these things can possibly happen with RMC's patented recalibration device.*



SHIPPINGPORT, Pa.—Heavy-duty dial thermometers play an important role in the operation of the world's first full-scale atomic-electric generating station devoted exclusively to civilian needs. These thermometers, manufactured by RMC, can be recalibrated externally. The plant is a joint project of Westinghouse Electric Corporation, Atomic Energy Commission and Duquesne Light Company of Pittsburgh.

A simple dial-reset screw, located on the back side of RMC thermometers, permits recalibration without opening the instrument in any way—thus leaving its air-tight hermetic seal intact. Its positive meshed-gear mechanism rotates the dial itself in a way that cannot under any circumstances cause damage to the pointer shaft. And the new setting will hold indefinitely.

Write, wire or phone—tell us your requirements for indicating instruments, and let RMC engineering skill go to work for you. ROCHESTER MFG. CO., 38 Rockwood St., Rochester 10, N. Y.

The simplicity of recalibrating an RMC bimetal dial thermometer is illustrated above. *Patented RMC system leaves hermetic seal undisturbed, prevents damaging of critical pointer shaft.*

RMC external recalibration device saves time and your thermometer

With the patented RMC dial reset screw you can recalibrate your thermometer easily and safely, should it ever be necessary. The all-important hermetic seal cannot be destroyed, and there is no chance for damage to the critical pointer shaft.

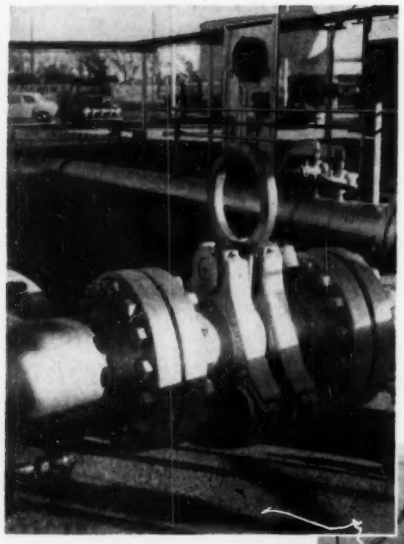
RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N. Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

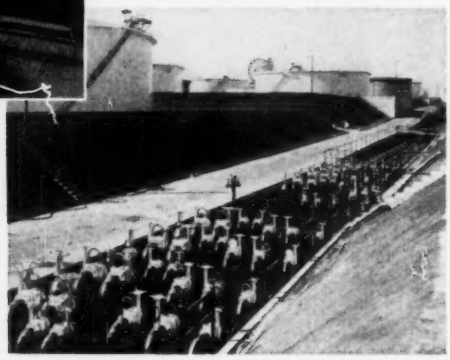
REPRESENTATIVES IN ALL PRINCIPAL CITIES

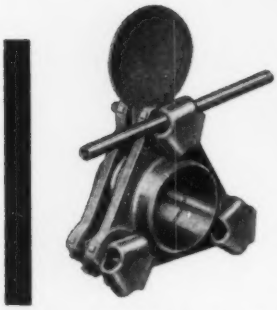
For more data on advertised products, use Readers' Service Cards, last page.



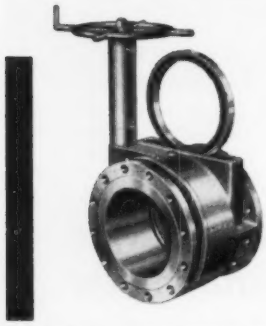
FAST, EASY, POSITIVE
LINE BLINDING

Hamer
Line Blind Valves





The famous 3-Bolt Hamer Line Blind Valve has set the standard for positive, dependable, economical line blinding in all industries.



Handwheel operated Hamer Rigid Type Line Blind Valves are ideal for installation where conditions prevent spreading the line to reverse the spectacle plate.

FAST . . . because one man can reverse the spectacle plate from open to closed position in a matter of minutes.

EASY . . . because bar or handwheel operation provides tremendous leverage for spreading and tightening the hubs that hold the spectacle plate. Wedges, hammers, wrenches needed for spreading conventional flanges are eliminated.

POSITIVE . . . because nothing seals as securely and permanently as the solid spectacle plate clamped between the hubs of a Hamer Line Blind Valve.

Ask your nearest Hamer Line Blind Valve specialist about the multiple advantages of installing them wherever positive line shut-off is essential. Write for new Hamer Valve Catalog 60.

WECO

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS
Division of CHIKSAN COMPANY *a subsidiary of* FOOD MACHINERY AND CHEMICAL CORPORATION

HV-2-60

fmc

WECO UNIONS

CHIKSAN SWIVEL JOINTS

HAMER LINE BLIND VALVES

HAMER PLUG VALVES

Changing Times (continued)

business of Tennessee Gas Transmission Co. and Tenneco Oil Co. is in the hands of a new firm—Tenneco Corp. The new company will own and operate all non-pipeline properties of Tennessee Gas.

Houston Chemical Corp. and Great Lakes Chemical Corp. are equal partners in the new company, Arkansas Chemicals, Inc. The company will sell most of its bromine to Houston for conversion to ethylene dibromide.

Montecatini sues Shin Nippon Chisso for infringement of polypropylene patents. Montecatini, according to a company spokesman, was forced into this action after the Japanese firm failed to heed warnings.

Australian refineries produced a record 7,360,000 gallons of LPG in the year ending June 30, 1960. This was seven times the production of five years ago when Australia first began making LPG.

Private industry will quadruple its spending for research in the next decade, according to Arthur D. Little, Inc. The firm believes that the current $4.5-billion spending will zoom to a staggering $16.5 billion by 1969.

Houdry Process Corp. and Commonwealth Oil Refining Co., Inc., make an amicable settlement of litigation pending in New York and Puerto Rico for over two years.

Grants amounting to $41,200 made by Creole Petroleum Corp. to 40 U.S. Colleges and universities. The donations are being awarded as collateral grants to institutions at which 67 scholarship students from Venezuela are enrolled.

Research fellowships amounting to about $60,000 awarded by Ethyl Corp. in chemistry, chemical engineering, mechanical engineering, industrial engineering and science teaching for 1960-61 academic year.

The Huffman and Western States Gasoline plants at Kettleman Hills will be operated by Standard Oil Co. of California, Western Operations, Inc. The plants are currently operated by P. S. Magruder.

OCAW locals at Pure Oil Co.'s Smiths Bluff (Nederland, Texas), Toledo, Ohio, and Lemont Ill., refineries accept 14-cent hourly wage hikes under one-year contract extensions. Negotiators for an independent union at the company's Heath refinery has settled for a 5 percent boost.

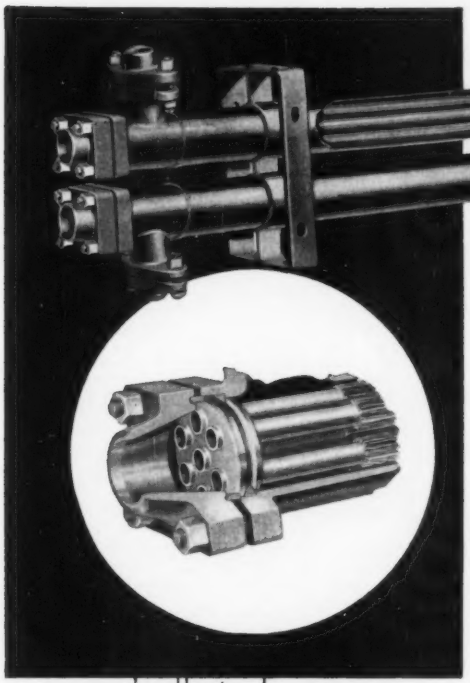
Texas City Refining, Inc., buys Sid Richardson Refining Co.'s refining and terminal properties in Texas City.

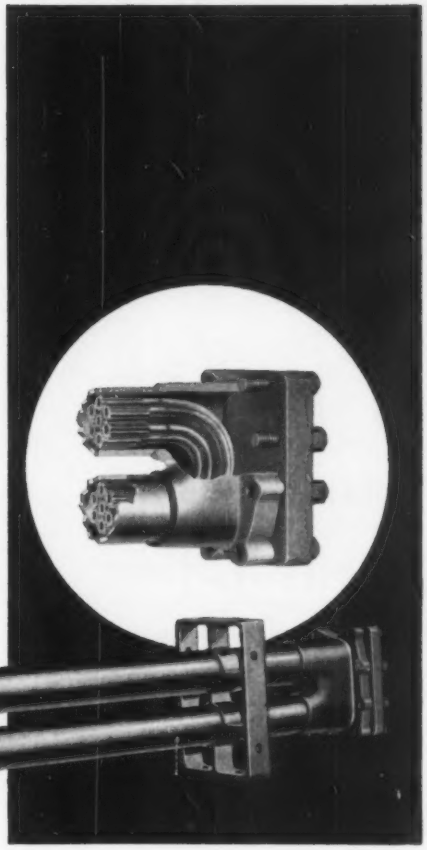
For more data on advertised products, use Readers' Service Cards, last page.

Cost-saving standardization available in

scores of new duties with NEW

MULTI-FINTUBE EXCHANGERS

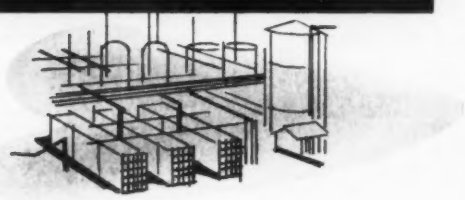




Patent Pending

Now, many additional duties can be handled with hairpin type heat exchangers economically and efficiently. A new multi-fintube section developed by Brown thermal engineers incorporates a bundle of finned tubes within each shell. Heat transfer capacity is sharply increased to the point where one new multi-fintube section does the work of up to four conventional single fintube sections. Brown multi-fintube units handle conventional duties at much lower cost. Due to their increased fin efficiency the multi-fintube sections have increased the scope of application for this type of heat exchanger equipment. Typical examples of applications are light hydrocarbon exchangers, condensers, coolers, and water to water exchangers.

Write for Bulletin 111 on Brown's new multi-fintube units. Brown Fintube Company, Dept. PR-1, 300 Huron Street, Elyria, Ohio.



BROWN STANDARDIZATION REDUCES COSTS

- **LOWER INSTALLATION COSTS**—Only one type unit to install.
- **NO OBSOLESCENCE**—As duties change, units are used in new banks.
- **EASIER MAINTENANCE**—Only one type to service.
- **LOW PARTS COSTS**—Only four parts for hundreds of exchangers.
- **NO DOWNTIME**—Valving permits any unit to be serviced while others operate.
- **STANDBYS READILY AVAILABLE**—One unit serves as a standby.
- **IMMEDIATE DELIVERY**—From U.S.A., Canada, England, France, Germany, Japan and Mexico.

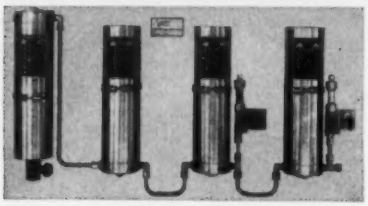
HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

BROWN FINTUBE

SYMBOL OF EFFICIENCY IN HEAT TRANSFER PRODUCTS

For more data on advertised products, use Readers' Service Cards, last page.

When water or oil in gases cannot be tolerated . . .



INSTALL ROBBINS

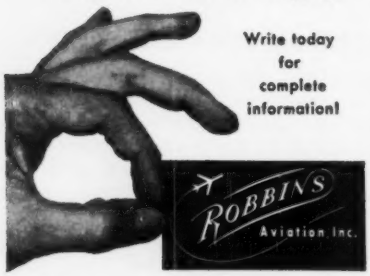
dehydration equipment

Robbins Aviation offers you both disposable cartridge type and refrigeration type dehydration systems for practically all types of gases . . . equipment designed and built to rigid quality control standards to give you maximum satisfaction in efficient trouble-free performance.

Robbins equipment is used extensively for aircraft pneumatic systems, test laboratory equipment, mobile compressor trailers, hydraulic system purging, missile charging and pressurizing systems, for instrument, laboratory, and factory air, controlled atmospheres for brazing and heat-treating furnaces, etc. Mechanical filters, drier and purifier chambers, refillable and disposable cartridges, dewpoint indicators also available.

Fast, positive, economical removal of water or oil vapor and impurities

Pressures to . . . . . 12,000 PSI
Safety Factor . . . . . 4 to 1
Dewpoints to . . . . . −100°F
Oil Vapor Removed to . . . as low as 0.3 ppm/w



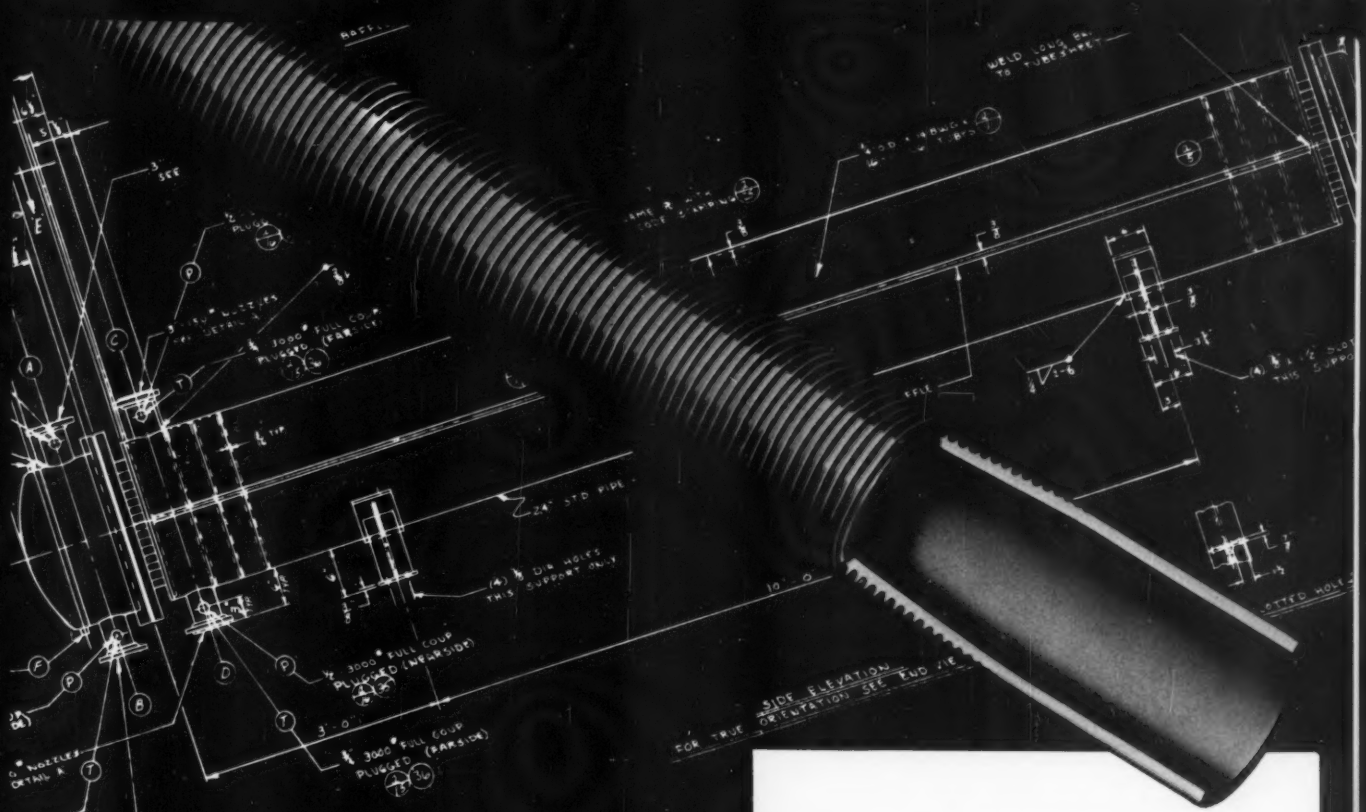
Write today for complete information!

Manufacturers of high quality valves and dehydration equipment

2350 E. 38th St., Los Angeles 58, Calif.
LUdlow 9-5221

Meetings Calendar

Jan. 1961	
16-19	**Instrument Society of America,** Conference & Exhibit, Winter Instrument-Automation, Sheraton-Jefferson Hotel, Kiel Auditorium, St. Louis, Mo.
-20	**Natural Gasoline Association of America,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.
23-26	**Plant Maintenance & Engineering Show,** Conference, International Amphitheatre, Chicago.
23-Feb. 2	**Engineering and Management Course,** University of California, Los Angeles, Calif.
24-27	**Society of Plastics Engineers,** Annual Technical Conference, Shoreham Hotel, Washington, D.C.
25-27	**Instrumentation for the Process Industries,** A & M College, College Station, Texas.
25-27	**Technical Report Writing Extension Course,** University of Wisconsin, Madison, Wis.
26-27	**Symposium on Hydrocarbon Chemistry,** Shamrock Hilton Hotel, Houston, Texas.
Feb.	
13-15	**American Industrial Writing Institute,** Western Industrial Writing Institute, Los Angeles Statler-Hilton Hotel, Los Angeles, Calif.
15-16	**Western Petroleum Refiners' Association,** Gulf Coast Regional Technical-Industrial Relations Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.
-24	**NGAA,** South Louisiana Regional Meeting, Lafayette Petroleum Club, Lafayette, La.
26-Mar. 1	**American Institute of Chemical Engineers,** Petrochemical and Refining Exposition, Municipal Auditorium, New Orleans, La.
26-Mar. 2	**American Institute of Mechanical Engineers,** Annual Meeting, Chase & Park Plaza Hotels, St. Louis, Mo.
Mar.	
5- 9	**American Society of Mechanical Engineers,** Gas Turbine Power Conference & Exhibit, Shoreham Hotel, Washington, D.C.
13-17	**National Association of Corrosion Engineers,** Annual Meeting & Corrosion Show, Hotel Statler, Buffalo, N.Y.
15-17	**NGAA,** Annual Convention, The Baker Hotel, Dallas, Texas.
21-23	**American Power Conference,** Sherman Hotel, Chicago, Ill.
21-30	**American Chemical Society,** National Meeting, St. Louis, Mo.
27-31	**ISA,** Symposium on Temperature—Its Measurement and Control in Science and Industry, Veterans' Memorial Auditorium, Columbus, Ohio.
28-29	**Gas Conditioning Course,** University of Oklahoma, Norman, Okla.
April	
10-11	**ASME,** Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.
10-12	**WPRA,** Annual Meeting, Grenada Hotel, San Antonio, Texas.
10-14	**Safety Engineering Course,** University of Oklahoma, Norman, Okla.
17-19	**ISA,** National Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Texas.
18-20	**American Welding Society,** Meeting and Show, Commodore Hotel, New York.
18-20	**Gas Measurement Short Course,** University of Oklahoma, Norman, Okla.
-28	**NGAA,** Oklahoma Regional Meeting, Lake Murray Lodge, Ardmore, Okla.
30-May 2	**Independent Petroleum Association of America,** Midyear Meeting, Roosevelt Hotel, New Orleans, La.
May	
8-10	**ISA,** National Power Instrumentation Symposium, LaSalle Hotel, Chicago, Ill.
8-11	**American Petroleum Institute,** Division of Refining, Midyear Meeting, Rice Hotel, Houston, Texas.
8-12	**API,** Accident Prevention and Fire Protection Meetings, Statler-Hilton Hotel, Detroit.
-19	**NGAA,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
22-24	**ISA, AIEE, ARS, IAS, IRE,** National Telemetering Conference, Chicago.
23-24	**WPRA,** Mid-Continent Regional Technical-Industrial Relations Meeting, Hotel Lassen, Wichita, Kan.
June	
5- 8	**ISA,** Summer Instrument-Automation Conference & Exhibit, Royal York Hotel, Queen Elizabeth Hall, Toronto, Ont.
-12	**ISA,** Air Pollution Control Association, Air Pollution Instrumentation Symposium, Hotel Commodore, New York City.
12-16	**Technical Writer's Institute,** Rensselaer Polytechnic Institute, Troy, N.Y.
13-16	**ISA,** Gas Chromatography Symposium, Kellogg Center, Michigan State University, East Lansing, Mich.
14-15	**WPRA,** Refiners' Computer Conference, Site and Location Unreported.



Wolverine TRUFIN® and STEEL ...go together—naturally!

Where corrosion is not a problem—design and operating engineers are finding that they can cash in on money-saving benefits by specifying Wolverine Trufin Type S/T (19 fins per inch) in seamless steel.

Trufin – in steel – possesses all of the inherent advantages of integral finned tube. For example:

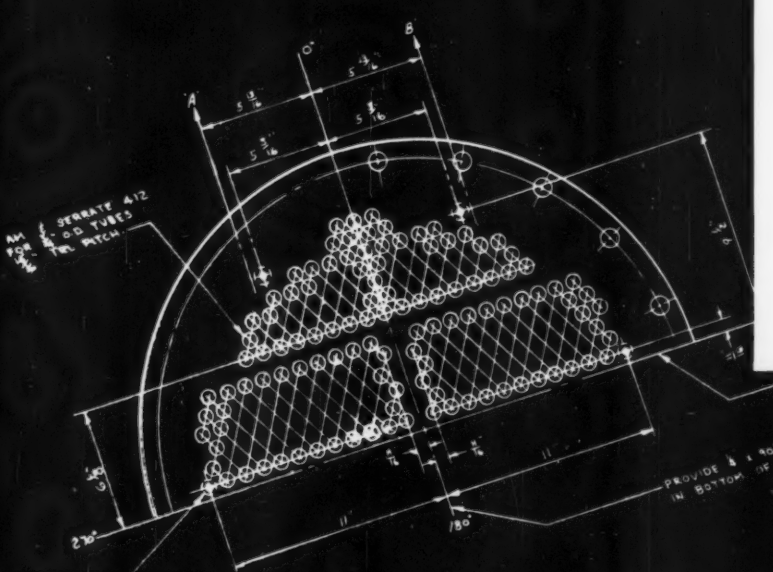
* **In new installations** – Trufin lets you design smaller exchangers without sacrificing capacity. You save on shells, headers, baffles, supports, etc.

* **When retubing** – Trufin's extended surface makes it possible to dramatically increase the capacity of existing exchangers. Trufin Type S/T can be substituted directly for bare tube.

* **Trufin has stamina** – Trufin, because of its integral fins, has the ability to stand up under rigorous operating conditions. Fins are part of the tube wall and are unaffected by the pounding of temperature and pressure changes and vibrations.

Trufin is produced in many types, sizes, and fin spacings – and in steel, copper, copper alloys and aluminum.

WRITE TODAY FOR MORE INFORMATION.



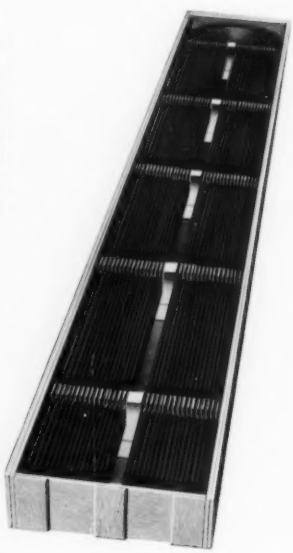
Look to Wolverine for the complete line of finned tube

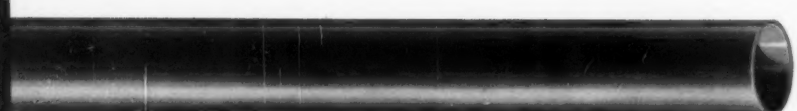
Trufin Type S/T | Trufin Type W/H | Trufin Type S/T (Duplex) | Trufin Type L/C (Bimetal) | Trufin Type H/R | Trufin Type H/A | Trufin Type I/L

Only Wolverine Tube Division of Calumet & Hecla, Inc. can supply you with such a complete line of integrally finned tube – seven different types designed to bring increased efficiency to a wide variety of heat transfer applications. Each type is available in a complete range of sizes and alloys. Ask your Wolverine salesman for information about how these outstanding tubes can help you.

WOLVERINE ALSO OFFERS SPECIAL SERVICES AND SPECIAL PRODUCTS

Wolverine's Field Engineering Service is staffed with specialists trained in tubing selection, alloys, metallurgy, equipment design, etc. Also available for consultation are Wolverine's Heat Transfer Specialists who are located throughout the major processing areas. The services of all these men are yours —without obligation.





. . . AND, OF COURSE, WOLVERINE TUBE also manufactures a complete line of copper, copper alloy and aluminum prime surface condenser tube. Ask your Wolverine sales representative about Wolverine's complete line of products and services.

Wolverine Tube is also a prime mill source for palletized U-bend condenser tubes—manufactures them to your "specs" and ships them to you in disposable box-type pallets so that you can feed directly from pallet to condenser.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. I, 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

Men in HPI...

McKetta

Healy

Dr. John J. McKetta, professor and chairman of the Department of Chemical Engineering at The University of Texas, has been elected vice president, American Institute of Chemical Engineers. Dr. McKetta has been connected with the University of Texas since 1946, when he was appointed associate professor of chemical engineering. He has been chairman of the Department of Chemical Engineering since 1949, and was made a full professor in 1951. He received a B.S. degree in chemical engineering from Tri-State College, and M.S. and Ph.D. degrees from the University of Michigan. He is chairman of the Editorial Committee of PETROLEUM REFINER, and a member of the board of directors, Gulf Publishing Co.

John J. Healy, an executive of Monsanto Chemical Co., St. Louis, Mo., has been named president of the American Institute of Chemical Engineers. Healy graduated from Harvard College in 1919 with a bachelor of arts degree, and received a bachelor of science degree in chemical engineering from the Massachusetts Institute of Technology in 1921. He has been with Monsanto Chemical Co. since 1929, and is currently a member of its corporate planning group. Active in AIChE for years, Healy has served two terms as a director, has represented the institute on the Engineering Manpower Commission and has served as chairman of the Boston section.

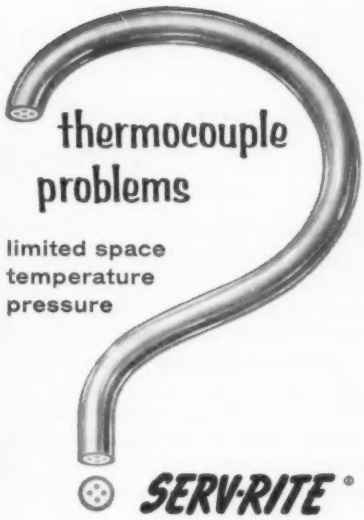
John K. McKinley has been appointed general manager of Texaco, Inc.'s, Petrochemical Department. McKinley was formerly manager of commercial development processes in the company's Research and Technical Department at Beacon, N. Y. He was first employed by Texaco as a chemical engineer at the Port Arthur plant in 1941. In 1954 he became supervisor of the Cracking Research Department and was made assistant director of research shortly after his transfer to Beacon in 1956.

McKinley

J. B. St. Clair has been named superintendent, Shell Oil Co.'s Houston refinery. He succeeds **A. J. Wood** who will become manager, oil and research development, at Shell Development Co.'s Emeryville, Calif., research center. St. Clair received his bachelor's degree in chemical engineering from Tulane University. He joined Shell in 1940 as a technologist at the Houston refinery.

Robert L. Kidd has been elected chairman of the board and **J. Edgar Heston** has been named president, Cities Service Oil Co. Kidd, who has been president of the company since 1956, will continue as its chief executive officer. Heston, who has served as president of Arkansas Fuel Oil Corp. since 1956, with headquarters in Shreveport, La., will continue in that position.

H. D. Carlson has been elected a vice president of Southwestern Engineering Co., Los Angeles, and named manager of the company's Engineering and Construction Division. The firm has also announced the appointments of engineering personnel: **R. D. Koons,** manager of engineering; **W. K. Ingram,** manager of construction; **R. Gilman,** chief of mate-



SERV-RITE®

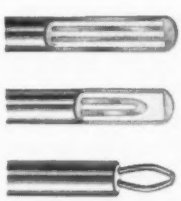
Premium Sheathed Thermocouples

(.020" to .500" O.D.)

Problems of space limitation, temperature, or pressure are solved with SERV-RITE *premium* sheathed thermocouple wire. For maximum sensitivity, accuracy and quick response, SERV-RITE will furnish the best service for your dollar.

Featuring hard-pack insulation with heavy wall construction, SERV-RITE is fully flexible and can be bent to suit requirements. In addition to a choice of junction tips, fittings and connectors, SERV-RITE *premium* sheathed wire is available in a wide range of sheath materials, bright annealed. Standard and special thermocouples are made to suit any need.

All wires used in SERV-RITE *premium* sheathed thermocouple wire are selected and matched to conform to "Special" limits of error as set forth by I.S.A. Recommended Practice, R.P. 1.3. This wire meets the strictest over-all specifications.



Ask for BULLETIN 1200-4

for complete details, ordering data, and prices on SERV-RITE *premium* sheathed thermocouple wires and accessories.

8763

CP

CLAUD S. GORDON CO.

Manufacturers • Engineers • Distributors

615 West 30th Street, Chicago 16, Illinois
2019 Hamilton Ave., Cleveland 14, Ohio

For more data on advertised products, use Readers' Service Cards, last page.

Trapping Standardization

. . . steam trap standardization plus standardized hook-ups spell lower maintenance costs

An important weapon in the fight against rising maintenance costs is standardization. It can reduce the variety of maintenance problems and simplify those which remain.

Since we specialize in steam traps we'd like to offer some suggestions for a trapping standardization program. Such a program involves standardization on one make of trap and standardization of hook-ups.

Trap Standardization

The advantages of standardizing on a single make of trap are important and can make a big difference in the cost and ease of repairs because—

1. You can carry a more complete stock of repair parts with a smaller inventory.

2. Maintenance personnel has the opportunity to become expert on one make rather than be "jacks of all traps."

3. As an exclusive user of one make of traps you become a preferred customer of your trap representative and can be sure of getting the best possible service.

4. You can enjoy the advantages of standardized hook-ups.

Standardized Hook-ups

Standardized hook-ups facilitate and reduce the cost of both original installation and maintenance. By adopting standards for the dimensions of all fittings, including nipples, each hook-up for a given size of trap is identical and can be fabricated in the pipe shop.

Unions should be used so that when a trap needs repair, the unions can be uncoupled, the trap lifted from the line and a spare carrying identical length nipples and half unions slipped into place. In as little as a minute or two a faulty trap can be replaced. The faulty trap can go back to the storeroom for repair when convenient and then be put into stock as a spare.

Figure 1 shows a typical standardized hook-up used by a major chemical manufacturer. Note how

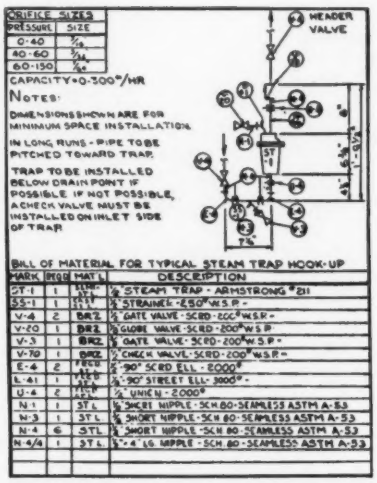

ORIFICE SIZES
PRESSURE SIZE
0-40
40-60
60-150
CAPACITY 0-300#/HR
NOTES:
DIMENSIONS SHOWN ARE FOR MINIMUM SPACE INSTALLATION.
IN LONG RUNS - PIPE TO BE PITCHED TOWARD TRAP.
TRAP TO BE INSTALLED BELOW DRAIN POINT IF POSSIBLE. IF NOT POSSIBLE, A CHECK VALVE MUST BE INSTALLED ON INLET SIDE OF TRAP.
HEADER VALVE
BILL OF MATERIAL FOR TYPICAL STEAM TRAP HOOK-UP
MARK REQD MAT'L DESCRIPTION
ST-1 1 STEAM TRAP - ARMSTRONG #211
SS-1 1 STL 1/2" STRAINER - 250# W.S.P. -
V-4 2 BRZ 1/2" GATE VALVE - SCRD - 200# W.S.P. -
V-20 1 BRZ 1/2" GLOBE VALVE - SCRD - 200# W.S.P.
V-3 1 BRZ 1/2" GATE VALVE - SCRD - 200# W.S.P. -
V-70 1 BRZ 1/2" CHECK VALVE - SCRD - 200# W.S.P. -
E-4 2 MALL 1/2" - 90° SCRD ELL - 2000#
E-41 1 MALL 1/2" - 90° STREET ELL - 3000# -
U-4 2 MALL 1/2" UNION - 2000#
N-1 1 STL 1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-3 1 STL 1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4 6 STL 1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N 4/4 1 STL 3/4" x 4" LG NIPPLE - SCH 80 - SEAMLESS ASTM A-53

Fig. 1—Typical standardized installation hook-up used by a leading chemical manufacturer.

the hook-up provides the following advantages:

1. Test valve in trap cap permits fast, easy checking of trap operation.

2. Strainer ahead of trap protects it against dirt and scale.

3. Blowdown valve in strainer provides easy cleaning.

4. Check valve in discharge line isolates trap when test valve is opened.

5. Shut-off valves and unions ahead of and following trap permit removal of entire trap from line.

Fig. 2—Armstrong traps have only two moving parts—the lever assembly and the bucket. Nothing much to go wrong here.

Another important consideration for getting the most from a standardization program is accessibility of the traps. Insofar as is possible, traps should be located so that they are convenient for inspection. The easier it is to locate and get at a trap, the less likelihood that it will be overlooked.

What Make of Trap? (This is the Commercial)

Obviously, a trap standardization program shows the best results when the make of trap selected is the one that gives the best service. Naturally, we think the make should be Armstrong and fortunately a lot of trap users agree. Here are some of the advantages of standardizing on Armstrong that have been pointed out by these users:

1. *Armstrong traps work.* They don't leak steam and they do discharge condensate and air as fast as they reach the trap. And they work with any return system.

2. *Armstrong traps aren't "prima donnas."* They need no special care or coddling. Valve and seat are hardened chrome steel. Lever assembly and bucket are stainless steel and these are the only moving parts.

3. *Armstrong traps aren't "orphans."* You can *always* get parts and service from nearby Factory Representatives and stocking distributors.

4. *Armstrong traps are guaranteed.* If you're not *completely* satisfied you can return the traps for refund of purchase price.

More Information

The 44-page Steam Trap Book (free on request) gives a lot more facts on trap selection and installation. Call your local Armstrong Representative or write **Armstrong Machine Works, 8527 Maple St., Three Rivers, Michigan.**

ARMSTRONG STEAM TRAPS

Men . . .

rial section; **P. Wendel,** chief electrical engineer; **J. Locke,** chief instrument engineer; **F. B. Odasz,** chief process engineer; **W. B. Dyer,** chief structual engineer, and **H. C. Morrison,** chief mechanical engineer.

Joel H. Hirsch, formerly chief development engineer at Gulf Research & Development Co., Harmarville, Pa., has been appointed director of the Development Engineering Division. Prior to joining GR&DC in 1944, as head of its process research engineering section, Chemistry Division, Hirsch was engaged in plant-scale test work, process design of thermal and catalytic cracking units, and technical supervision of development work and pilot plant activities with firms in the chemical industry.

J. N. Chatfield has rejoined Humble Oil & Refining Co.'s Humble Division, Baytown, Texas. He is a staff engineer in the Technical Division, serving as a corrosion engineering consultant and chemical cleaning specialist.

C. D. Owens, Jr., has been named director of personnel for Sinclair Oil Corp. and its subsidiaries. Owens, who joined Sinclair at Tulsa, Okla., in 1949, is a graduate of Oklahoma University's School of Law, and received his undergraduate education in liberal arts and chemical engineering at the Universities of Oklahoma, Illinois and Syracuse. He became manager of industrial relations for Sinclair's producing subsidiary in 1957 and has, for the past year, been a member of Sinclair's Industrial Relations Department in New York City.

Owens

Hans R. Wolfe has joined the Ethyl Corp. research laboratories in Detroit as a chemical engineer in the Refinery Technology Division. He received his B.S in chemistry and mathematics from the University of Nevada in 1947. Prior to joining Ethyl, he was with Lago Oil and Transport Co. in the Netherlands from 1947 to 1959 and with Creole Petroleum Corp. in Venezuela from 1959 to 1960. **Charles P. Talbott** has joined Ethyl research laboratories in Detroit as a technical analyst writer in the information services group.

John J. Zullo has been appointed plant manager of American Chemical Corp. American Chemical is a wholly owned subsidiary of the Stauffer Chemical Co. and Richfield Oil Corp. Zullo graduated from the Columbia University School of Engineering where he obtained both his bachelor and master of science degrees in chemical engineering.

Eugene W. Kane has been appointed supervisor, Projects Analysis Division, Crude Oil Planning Department, Standard Oil Co. (Indiana). With Standard for 13 years, Kane is presently a group leader, Research and Development Department, Whiting, Ind.

Thaddeus M. Reymont has joined the Research Department, Monsanto Chemical Co.'s Plastic Division plant, Texas City, after serving with Sundstrand Turbo Co. at Denver, Colo.

Jay L. Reed, formerly supervisor of employe relations, has been appointed manager of employe relations, Fluor Corp., Ltd. Reed joined Fluor in 1949 after receiving a degree in business administration from the University of Southern California.

David B. Ardern has been named an executive director of a new jointly-owned catalyst company in Marl, West Germany, by Houdry Process Corp. of Philadelphia and Chemische Werke Huels of Germany. Ardern, who leaves his post as director of technical service at Houdry, will be one of three executive directors of Katalysatorenwerke Houdry-

Three Smithco induced draft air cooled exchangers in the Houston plant of a world wide refiner.

All over the world engineers are turning to air as the solution of their heat transfer problems, even in areas where water is readily available. The reason? — AIR COOLING DOES THE JOB WITH THE SAME EFFICIENCY AS WATER, YET ELIMINATES THE NEED FOR COSTLY WATER TREATMENT, REQUIRES LESS MAINTENANCE AND PROVIDES A LONGER PERIOD BETWEEN "TURN AROUNDS".

Smithco, whose **only** business is air cooled heat exchangers, has pioneered many significant developments in this field. Prominent among these is the Smithco **Metalbond** Fintube. The Metalbond provides a continuous metallic path from the tube to the fin. This metallic bond assures highly efficient performance even at the elevated temperatures encountered in refinery and chemical services. It also eliminates the possibility of external corrosion of the tube.

A SMITHCO AIR COOLED EXCHANGER MAY BE THE ANSWER TO SAVING COOLING DOLLARS IN YOUR EXISTING PLANT.

SMITHCO
ENGINEERING INC

P O BOX 3217 PHONE GI 7-5545 TULSA, OKLAHOMA

For more data on advertised products, use Readers' Service Cards, last page.

AIR TOOLS

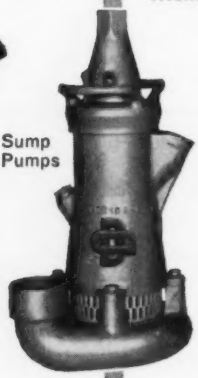
to cut your maintenance costs

Impact Wrenches

Paving Breakers

Clay Spaders

Piston Drills


Sump Pumps

Air Hoists

Backfill Tampers

PLUS . . .

concrete vibrators, utility drills, grinders, scalers, and other handy air-powered tools. See your Gardner-Denver air tool specialist or write for information.

Model RP125
Portable Air Compressor

Air power where you need it . . .

with Gardner-Denver Model RP rotary portable air compressors, sizes 85, 125, 210, 365, 600 and 900 cfm.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

Men . . .

Huels, G.m.b.H., a new company which will develop, manufacture and sell catalysts in the Western European market. Houdry named **Willis J. Cross** to succeed Ardern as director of technical service, and **Donald E. Womeldorph** to replace Cross as assistant director of technical service.

Paul J. LaMarche has been made vice president of production for U.S. Industrial Chemicals Co., Division of National Distillers and Chemical Corp. LaMarche joined the USI organization in 1949. From 1951 to 1958, he was manager of the company's plants at Ashtabula, Ohio. He become director of production in 1958.

LaMarche

John F. Eppler has been appointed a technical computing supervisor at the Whiting research laboratories. He will study how electronic computers can best be used to solve the many complex engineering problems involved in designing equipment for petroleum refining.

F. R. Hart has been elected the 27th president of the National Lubricating Grease Institute. Hart is supervisor of industrial and marine lubricants for the Standard Oil Co. of California. He had previously served as vice president and program chairman of NLGI. **C. L. Johnson,** president of Jesco Lubricants Co., Kansas City, has been named vice president of the institute.

F. H. Lacy, Jr., manager of the Natural Gas and Gasoline Department, Honolulu Oil Corp., has received the "Award for Meritorious Achievement" from the California Natural Gasoline Association.

Dr. Elroy J. Inchalik has been named head of the polymers process research section in the Chemicals Research Division, Esso Research and Engineering Co. Dr. Inchalik, with Esso Research since 1955, has worked on a variety of projects, including the oxidation and hydration of olefins and the synthesis of straight chain alcohols from metal alkyls.

Tyrone Z. Denessy has joined the Whiting research laboratories, Standard Oil Co. (Indiana). He will review and correlate foreign patents on technological developments of interest to the petroleum industry. Denessy, who obtained his chemistry degrees in Europe, was formerly with E. I. du Pont de Nemours & Co.

Justin Kimball has been named vice president, finance, Wilshire Oil Co. of

For more data on advertised products, use Readers' Service Cards, last page.

Refinery licks tough heat exchanger crisis with emergency tube service

A sudden tube failure at the Pure Oil Company's Refinery in Lemont, Illinois, recently put Bridgeport's condenser tube service to the test. The failure hit on Friday afternoon—just before business slowed down for the week end. Faced with the prospect of costly equipment down time, the refinery called Bridgeport's Chicago office to find out how fast new tubes could be supplied. Here's a round-the-clock story of how the emergency was licked.

Friday, 2:30 P. M.: Salesman from Bridgeport's Chicago office learns that Pure Oil needs 900 Admiralty condenser tubes, and fast.

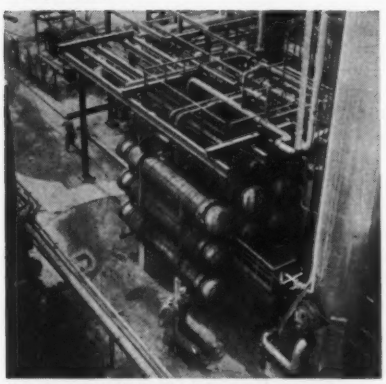
Friday, 3:00 P. M.: Salesman contacts our Bridgeport, Connecticut, mill and is informed that order can be delivered to Pure Oil Refinery in one week.

Friday, 3:30 P. M.: Sudden change in customer's needs makes immediate delivery of tubes imperative.

Friday, 4:15 P. M.: Chicago office checks through coast to coast network of Bridgeport warehouse stocks. Locates tubes at Beaumont, Texas.

Friday, 4:30 P. M.: Special night shift at Beaumont is put on job to cut tubes to special lengths and pack for shipment.

Saturday, 4:00 A. M.: Special truck leaves Beaumont, Texas, with order for Pure Oil Refinery in Lemont, Illinois.



Sunday, 11:30 P. M.: Truck arrives at Lemont Refinery with 900 Admiralty tubes, ready for repair work to start Monday morning.

While emergencies like this don't happen every day, they do prove dramatically that Bridgeport's customer service can come to the rescue. When we talk about fast service from our network of sales offices and warehouses, we mean it. Let us tell you more about our service on your condenser and heat exchanger tube needs, whether they're emergencies or normal deliveries. Call your nearest Bridgeport Sales Office, or get in touch with us direct.

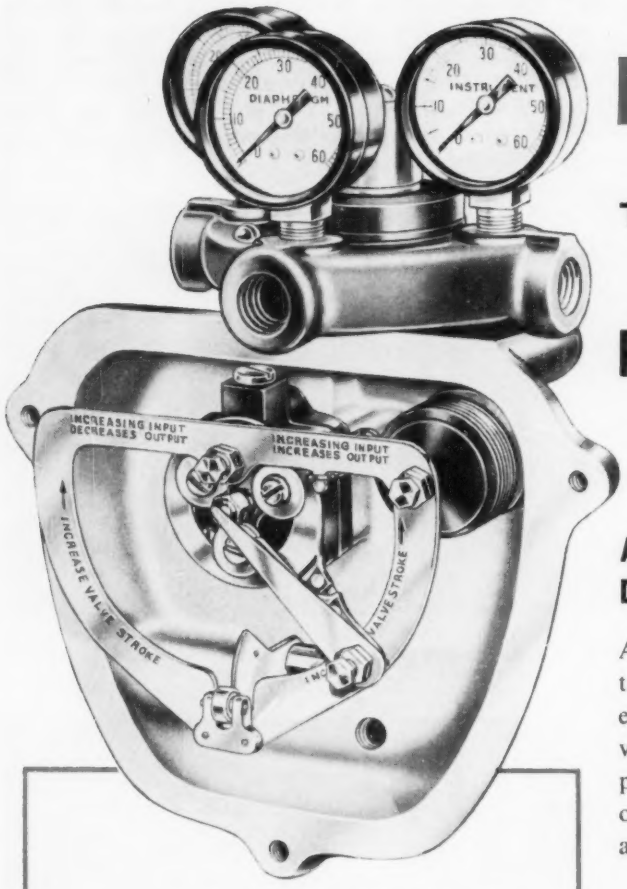
Write for your free copy of Bridgeport's Condenser and Heat Exchanger Tube Handbook. (Dept. 5302)

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from **A***luminum to* **Z***irconium*

A new concept in design makes possible the...



FISHER

TYPE 3560 VALVE POSITIONER

V/P

Assured product performance through DYNAMIC ANALYSIS engineering

Application of mathematical techniques of design to pressure control systems has enabled Fisher to eliminate the conventional approach in the development of the new V/P valve positioner. It has provided the V/P with the following combination of characteristics and performance . . . unobtainable in any other type of valve positioner.

SMALL AND COMPACT . . . only 6⅝" wide and 8¾" high (with gauges).

CONVENIENT ADJUSTMENT . . . valve stroke and zero adjustment readily accessible and easy to make.

SPLIT RANGE . . . no parts change whatsoever is required for split range operation.

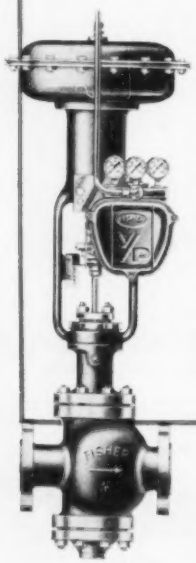
EASILY REVERSIBLE . . . reversed by simply moving flapper arm from one beam quadrant to the opposite quadrant.

CHARACTERIZED CAMS . . . offer wide flexibility in valve characteristics.

PERFORMANCE DATA

Hysteresis, (Average)	0.0012"
Linearity	as required. Change cams to obtain desired characteristics
Sensitivity	0.14 psi
Resolution Sensitivity	0.002 psi
Repeatability	±0.0003"
Stroking Speed	0.37 in/sec.
Air Consumption	10 scfh
Break Frequency (5% of instrument pressure range)	3.9 cps
Break Frequency (3% of instrument pressure range)	4.6 cps

The above performance data was taken from laboratory tests on a Type 657 diaphragm actuator, Size 40, with 1½" travel. Instrument range 3 to 15 psi.



Write today for Bulletin E-3560

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT COMPANY, CORAOPOLIS, PA.

FISHER® Controls

SINCE 1880

Men . . .

California. He was formerly assistant to the controller for Hughes Tool Co. and served as controller for Quintana Petroleum Corp. and Forest Oil Corp. He graduated from Baylor University.

William J. Funk has been appointed manager of foreign projects, Refinery Division, Arthur G. McKee & Co. He will be in charge of coordinating engineering, purchasing, inspection and construction of foreign petroleum projects with the exception of those in Canada and Mexico. Funk has been with McKee's Refinery Division since 1948 when he joined the company's Engineering Department. He graduated from Iowa State University in 1948 with a B.S. degree in general engineering.

Funk

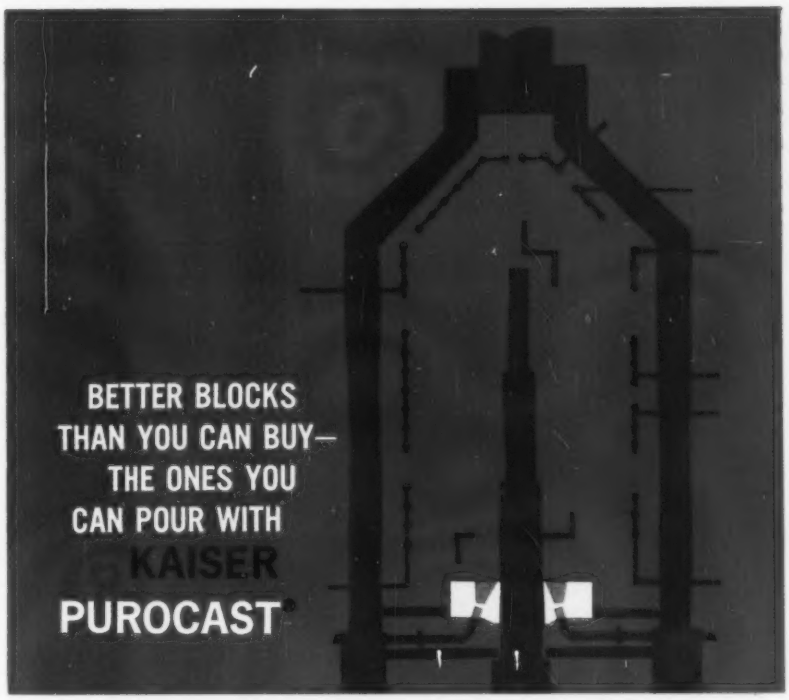
W. T. Jones has been promoted to senior chemical engineer, Process Technical Division, Baytown, Texas, refinery, Humble Oil & Refining Co.'s Humble Division. He is responsible for the technological control of light ends processing facilities, including the study of light ends fractionation and utilization, and increasing the production of aromatic specialties.

J. F. Thornton has been named assistant district superintendent and district engineer, Phillips Petroleum Co., in the Natural Gasoline Department's Oklahoma district at Oklahoma City. He replaces **E. F. Glasgow** who has been promoted to superintendent of the district. Thornton joined Phillips in 1934 after graduating from the University of North Dakota.

Dr. Vernon P. Dorweiler has been appointed technical-computing supervisor, Whiting research laboratories, Standard Oil Co. (Indiana). Since he joined Standard in 1958, Dr. Dorweiler has studied how electronic computers can best be used in scheduling refinery operations to assure maximum product quality.

Dr. Roger E. Hatton has been appointed a Development Department project manager for petroleum chemicals and functional fluids in Monsanto Chemical Co.'s Organic Chemicals Division at St. Louis, after serving in that division's Research Department as a group leader.

M. E. Pickett, Jr., has been made a vice president of Columbian Carbon (Canada), Ltd., and general manager of its Carbon Black and Pigment Division. Pickett graduated from Mississippi



Kaiser Purocast castable is a better refractory material than you can normally buy in factory-fired burner blocks. Carefully blended low-iron, high-purity ingredients give it high resistance to spalling. Its high density—140 pounds per cubic foot—effectively reduces corrosive slag penetration.

The characteristic volume stability of Purocast makes it particularly suitable for high temperature burner blocks in the refinery oil heater.

Ask your Kaiser Refractories Sales Engineer how you can make all of your own burner blocks with Purocast—in your plant—and get these advantages:

Longer life without failure. Good uses of unassigned manpower to cast blocks in advance. Reduced inventory. Freight savings. And assurance that you can replace any shape block 24 hours after pouring—regain full heating in as little as 48 hours!

Call or write Kaiser Refractories & Chemicals Division, Dept. P6011 Kaiser Aluminum & Chemical Sales, Inc., at any of the offices listed below:

KAISER REFRACTORIES

PITTSBURGH 22, PA. . . . 3 Gateway Center
MEXICO, MISSOURI . . . Mex-R-Co Building
OAKLAND 12, CALIF. . . 300 Lakeside Drive

KAISER REFRACTORIES, DEPT. P6011
KAISER CENTER, OAKLAND 12, CALIFORNIA

Please send me information about Kaiser Purocast with instructions for casting and curing burner blocks

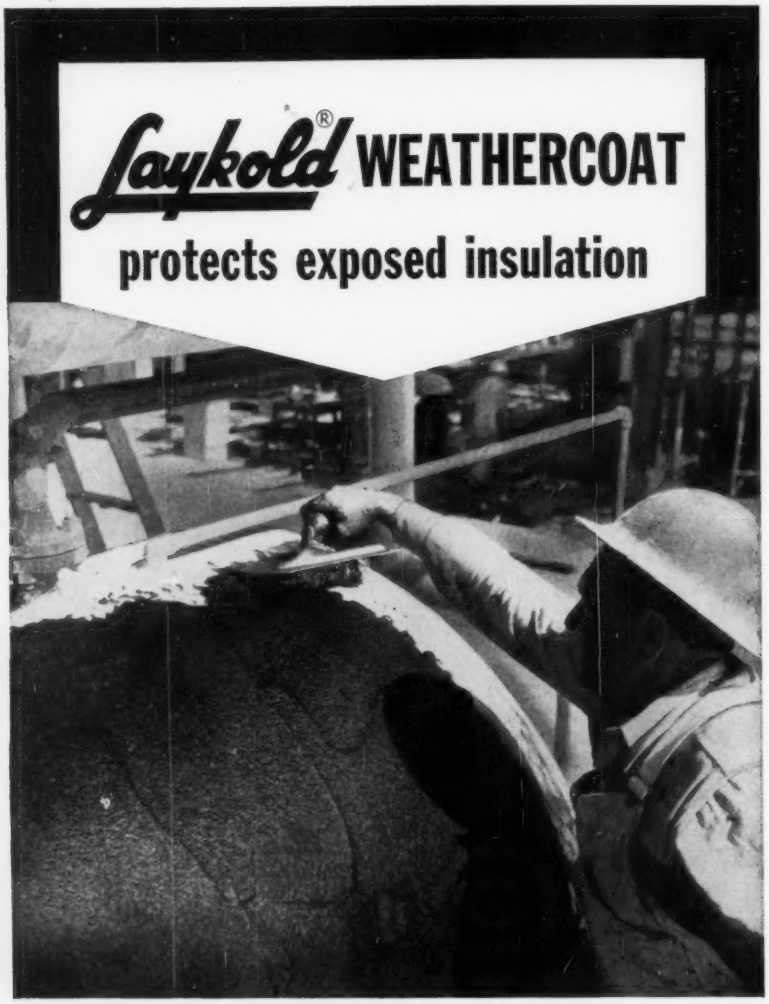
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

Write today for our free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

American Bitumuls & Asphalt Company

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Perth Amboy, N. J.
Baltimore 3, Md.
Cincinnati 38, Ohio
Atlanta 8, Ga.
Mobile, Ala.
St. Louis 17, Mo.
Tucson, Ariz.
Portland 8, Ore.
Oakland 1, Calif.
Inglewood, Calif.
San Juan 23, P. R.

BITUMULS® Emulsified Asphalts • CHEVRON® Paving Asphalts • LAYKOLD® Asphalt Specialties • PETROLASTIC® Industrial Asphalts

State University in 1942 with a B.S. degree in chemical engineering. He joined Columbian Carbon in 1945 and since 1957 has been supervisor of furnace and channel black quality control at the company's carbon black production headquarters in Monroe, La.

John F. Holohan, Jr., and D'Arcy C. Randall have joined the staff of the Whiting research laboratories, Standard Oil Co. (Indiana). Holohan will carry out pilot plant studies of new processes for making chemicals from petroleum products. Randall will work in the field of new applications for electronic computers.

Fred C. Riesenfeld has joined the staff of The Ralph M. Parsons Co. where he will serve as process development coordinator. Before joining the Parsons staff, Riesenfeld was chief research chemist with the Fluor Corp. Riesenfeld will work out of Parsons' Los Angeles office.

Riesenfeld

H. K. Arnold and M. Rosenbaum have been promoted to senior chemical engineers in the Technical Division, Baytown, Texas, refinery, Humble Oil & Refining Co.'s Humble Division. Arnold works with electronic computing machines for improving process operations and Rosenbaum handles problems in the long-range planning and development of major projects in all phases of fuels and specialties manufacture.

James N. Landis, vice president of the Bechtel Corp., San Francisco, has been elected president, Engineers Joint Council. The council is a national federation of 21 engineering societies organized to advance national and human welfare by promoting cooperation among the various specialties of engineering.

Billy Thompson, oil editor of the Houston Post, Houston, has been elected president of the Association of Petroleum Writers. Thompson succeeds **J. Richard Shaner** of Petroleum Week, New York. Thompson had served during the past year as vice president of APW.

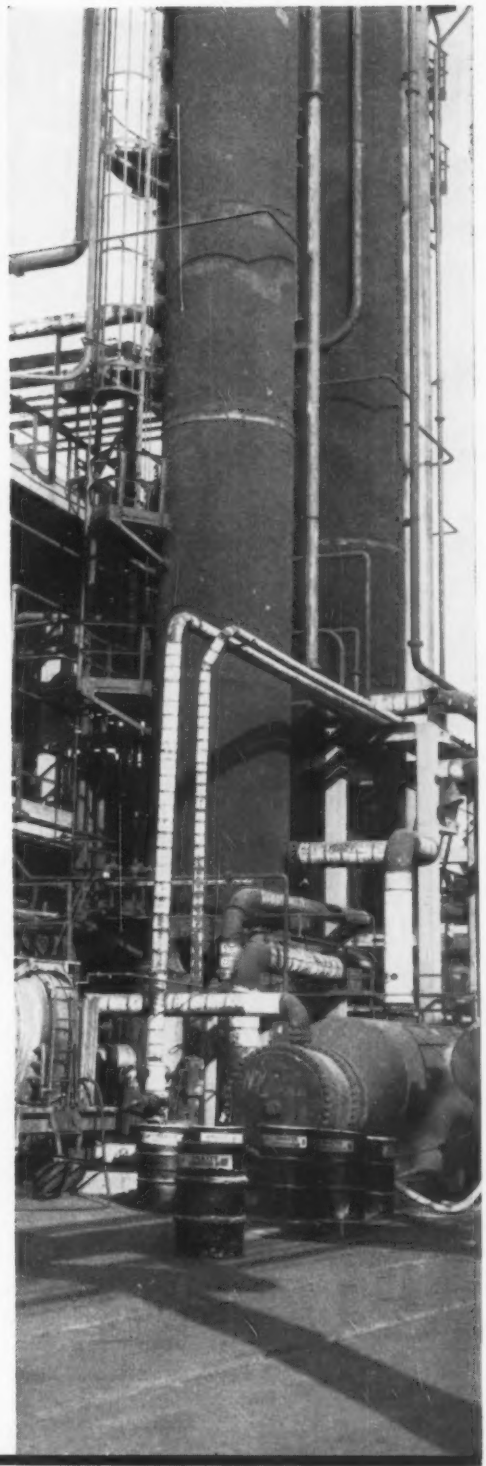
A. C. Martinsen has been appointed executive vice president and general manager of Catalytic Construction of Canada, Ltd. Martinsen, with 28 years experience in the engineering and construction industry has been with the Philadelphia firm since 1952 as manager of engineering.

Michael J. Gluck has been appointed vice president and general manager of Heyden Newport International Division.

For more data on advertised products, use Readers' Service Cards, last page.

Oakite ECP
engineered cleaning program

saves 3 days downtime with 1 drum of cleaner



Severe vibrations threatened to tear up a 30,000 cfm air blower before it reached even half-speed. Diagnosis: an oil leak from the previous run had probably carbonized on hidden areas of the impeller. A cat cracker, just getting back on-stream, was threatened with another three days downtime if the blower had to be taken apart.

Remedy: call the Oakite man. (An Oakite ECP includes *technical service.*)

The Oakite man proposed pumping a mixture of Oakite 8, water and steam into the blower—to clean it in-place. A few hours later refinery was able to put 160,000 lbs. of air per hour into their converter (the highest rate ever). This meant they were able to crack higher and increase gasoline, propane and butane yields. Downtime was eliminated; three day production loss (33,000 bbls.) avoided. ALL WITH ONE DRUM OF MATERIAL!!

WHAT IS OAKITE *ECP? ECP stands for Engineered Cleaning Program. It's a program of periodic chemical cleaning tailored for your refinery. It considers your equipment, conditions and through-put—itemizes your problems and the materials and methods to solve them.

But an ECP is much more than a standard program. It's the eagerness of the Oakite man to make *your* emergencies *his* concern. It's his experience in refinery cleaning, backed by the finest cleaning research facilities in the world, supported by materials *guaranteed* to work. Send for details. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

OAKITE
over 50 Est. 1909 years' leadership in industrial cleaning
SCIENCE

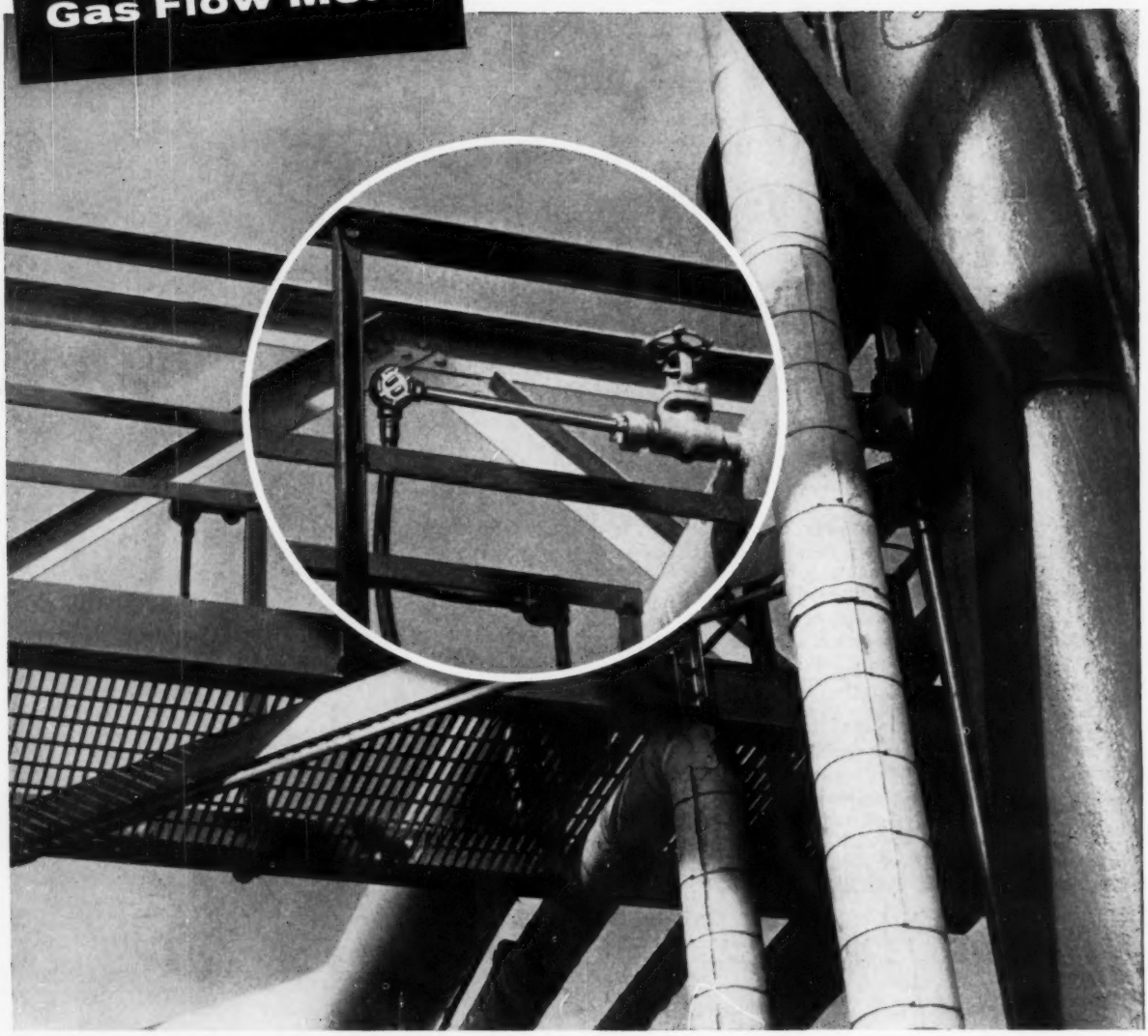
Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

For more data on advertised products, use Readers' Service Cards, last page.

"Anemotherm" Gas Flow Meter cuts flare stack losses



Are thousands of dollars going up your flare stack? You can substantially reduce these flaring losses with the "Anemotherm" *Probe-Type* Gas Flow Meter. This electronic, stainless steel instrument accurately measures the gas flow in the flare stack and the lines leading into it from various units. By determining flow rates and points of loss, refineries report savings of thousands of dollars per day.

Investigate the application of the "Anemotherm" Gas Flow Meter's wide range measurement, response to low velocities and available control functions in the following fields:

- *controlling atmospheric pollution*
- *increasing combustion efficiency in boilers, furnaces and heat treating equipment*
- *measuring the flow of air in catalytic cracking units*
- *metering the rate of flow in gas transmission lines.*

Put the money-saving accuracy and efficiency of the "Anemotherm" Gas Flow Meter to work for you. *Send for 8-page Technical Bulletin 5100 giving complete engineering data.*

ANEMOSTAT®

ANEMOSTAT CORPORATION OF AMERICA

10 East 39th Street, New York 16, N. Y.

Representatives in Principal Cities

AC 1379

Men . . .

A chemical engineer, Gluck has had experience in international operations as director of overseas activities for the corporation's Nuodex Products Division since 1956.

W. H. Dickinson has been named chairman of the Petroleum Industry Committee. Dickinson is with Esso Research and Engineering Co., Madison, N. J.

Clark P. Lattin, Jr., has been elected vice president in charge of petroleum and petrochemical development for Chemical Construction Corp. Lattin had been a vice president, member of the board of directors and member of the executive committee of Foster Wheeler Corp.

Ernest Cotton has been appointed departmental coordinator, Gulf Oil Corp., Manufacturing Department. He will be in charge of development of manufac-

Cotton

Manning

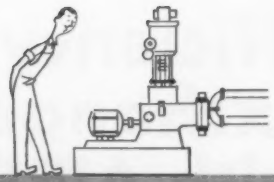
turing plans and economic analyses of departmental activities. **K. S. Manning** has been named coordinator, product supply, responsible for the development of the domestic product supply program for the department.

Dr. Chris A. Stiegman has been elected vice president, research and development, Hooker Chemical Corp. He was formerly director of research for the firm. Stiegman has been with Hooker for 23 years, joining the company in 1937 as technical assistant to the production manager.

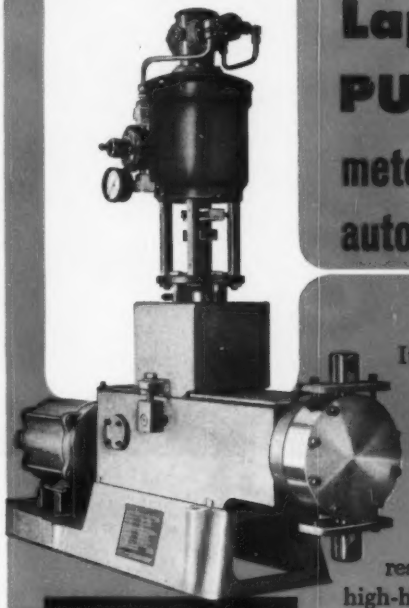
Carlton D. Weaver, William R. Seaton and Allan S. Perry have been named assistants to the executive management of Ashland Oil & Refining Co.

Jack H. Riddle, formerly chief of technical services for El Paso Natural Gas Products Co., has been promoted to division engineer responsible for all engineering at the products company's Odessa, Texas, complex. The Odessa unit consists of a butadiene plant, a styrene plant, and a complete refinery.

Dr. Soma Kurtis has been named assistant to the vice president, manufacturing Aurora Gasoline Co. He will serve



LOOK... NO HANDS!



Lapp

Lapp PULSAFEEDER meters liquid flow automatically!

It's strictly hands off with automated Pulsafeeders working in your process. These dependable pumps give you *automatically* controlled metering of liquids. They do it accurately and without resort to constant level controls, high-head tanks, measuring tanks or stuffing box pumps.

Here's how it works: A pneumatic or electronic instrument senses a change in the process condition. It then sends a signal to the Pulsafeeder, which interprets the signal and corrects its pumping rate *automatically*.

When liquids must be metered in proportion to changing process conditions—*and* in heavy production service—you can depend on the Lapp Pulsafeeder . . . the *trouble-free* automatic metering pump!

A NOTE on your letterhead will bring you Catalog 59 quickly. This new, complete, 28-page data book is chock-full of information on applications, specifications and descriptions of Pulsafeeders of a multitude of capacities and constructions. Write today . . . Lapp Insulator Co., Inc., Process Equipment Div., 1513 Poplar Street, LeRoy, New York.

For more data on advertised products, use Readers' Service Cards, last page.

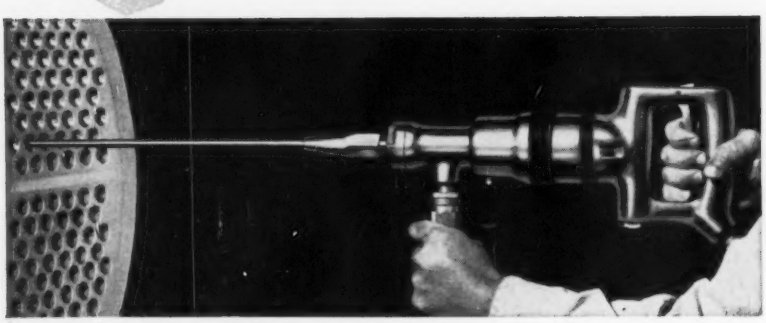
Efficiency of heat exchangers starts with AIRETOOL here

A complete line of efficient, powerful pneumatic tube cutters, cleaners and expanders.

AIRETROL

Compact, fast, efficient, easy to operate. Air-powered tube rolling up to twelve ¼" to 1½" OD tubes per minute. Precision pneumatic control stops expansion automatically within .001" of predetermined setting.

and here



Model CC-475 Lightweight condenser cleaner with air driven motor. Easy, one-man operation with no rig. Hard deposits and completely plugged tubes quickly and efficiently reamed out. Built-in flushing system washes cuttings away and cools the drill.

For complete information on Airetool pneumatic equipment for fabrication and maintenance of heat exchanger tubes, write today.

30 years experience in pneumatic tools

Branch Offices: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge **Representatives** in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii **European Plant:** Vlaardingen, The Netherlands **Canadian Plant:** Brantford, Ontario

Men . . .

in an advisory capacity to the vice president and will handle products control and refinery laboratory activities. He was formerly manager, Products Control Department. Succeeding Dr. Kurtis as products control manager is **C. E. Miller,** formerly assistant manager. **M. R. Doran, Jr.,** a coordinator, will move up to assistant manager.

George H. Oliver has been appointed manager of liquefied petroleum gas operations for Mobil International Oil Co. He joined the company in 1948 in industrial relations.

J. Ronald Getty has been appointed president and general manager of Veedol International. Veedol International directs the expanding operations of Tidewater Oil Co.'s European manufacturing and marketing subsidiaries other than Dansk Veedol, Tidewater's Danish-based subsidiary, which Getty will serve in an advisory capacity.

Dr. Robert E. Fariss has been named director of research for Hulburt Oil & Grease Co., Philadelphia. Dr. Fariss graduated from Rice Institute in 1942 with a B.S. degree in chemical engineering.

Elmer F. Hinner has been elected a vice president of Hercules Powder Co. He has been general manager of the company's Cellulose Products Department since 1954, and has been a member of Hercules' board of directors since 1952. Hinner has had the responsibility for the company's development in polyolefins.

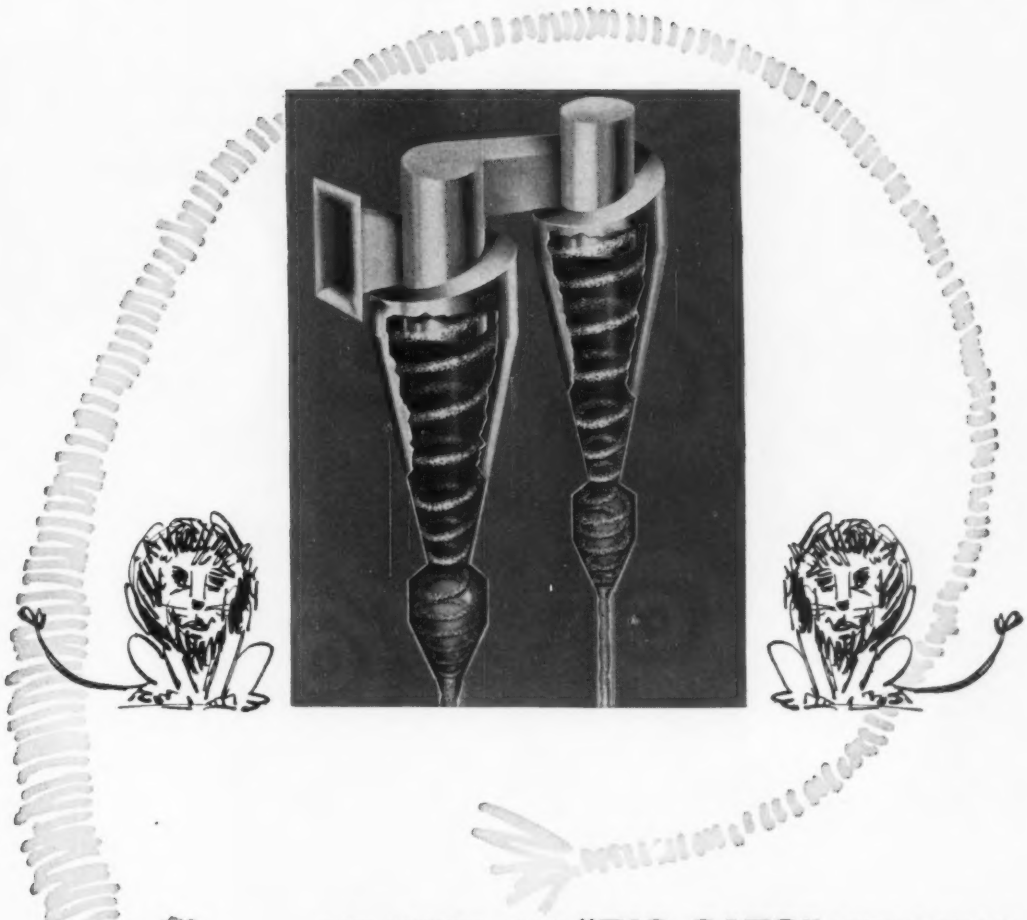
William E. Glenn, administrative assistant in the office of the president of Monsanto Chemical Co. at St. Louis, has been appointed administrative assistant to the chairman of the board of directors.

John S. Shaw, Jr., has been elected financial vice president, Southern Natural Gas Co. He will succeed **Howard M. Erskine** who has retired.

Arthur W. Steudel, president of Sherwin-Williams Co. since 1940, has been elected chairman of the board and chief executive officer of the company. The post has been vacant since 1944. **E. Colin Baldwin** has been named to succeed Steudel as president.

Wilbur L. Gay has joined the Whiting research laboratories, Standard Oil Co. (Indiana). He will conduct long-range economic studies of petroleum refining problems. Gay, who graduated from the University of Illinois, was formerly with Arabian American Oil Co.

S. J. Spitz, Jr., has been appointed president, Newport Industries Division, Heyden Newport Chemical Corp. Spitz



WE KEEP THE "BIG CATS" CRACKING

The "Big Cats," those steel behemoths that work wonders with the gasoline molecule, have a wild streak in them. Unless kept under control they can whip up a storm of flying catalyst dust that raises havoc with the operation and brings the Air Pollution Control people running.

To avoid this embarrassing and economically hazardous situation, refiners install our high efficiency SDC Duclones and Trickle Valves. They save money . . . improve performance . . . and in general do an admirable job. They snare each flying catalyst particle and plummet it back into the fluid bed to perform the miraculous task of catalytic cracking.

Is it any wonder that Duclones were used in two large refineries which set records for continuous on-stream service.

For more information on how SDC Duclones can keep "Big Cats" cracking, send for bulletin C-2058.

the name in DUst CONtrol

THE **Ducon** COMPANY INC.

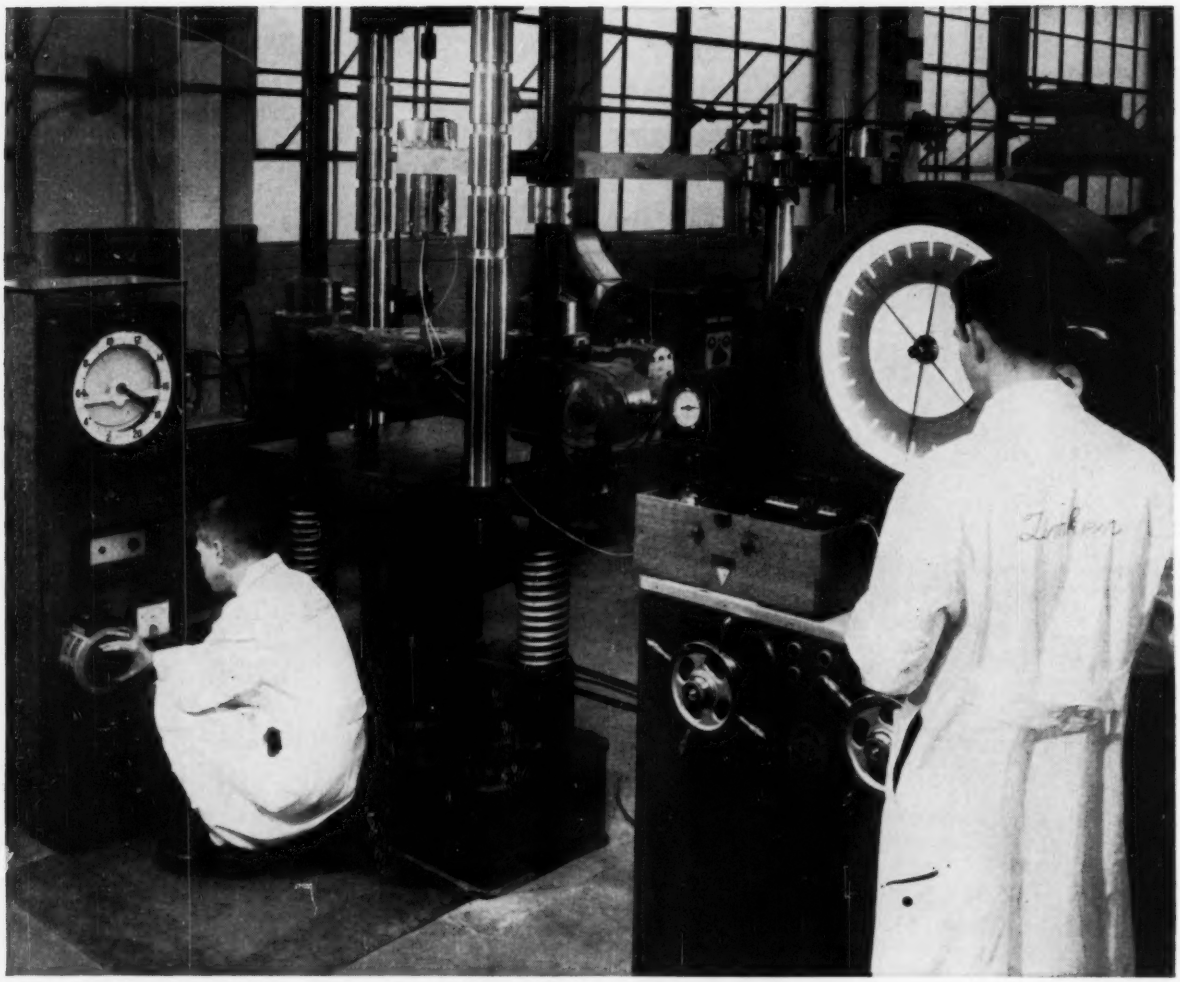
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

Canadian Branch:

THE DUCON COMPANY, of CANADA, Ltd., 1131 Pettit St., BURLINGTON, ONTARIO, CANADA

For more data on advertised products, use Readers' Service Cards, last page.



Here's where your "MAXIMUM TUBE LIFE PER DOLLAR" begins

If dollars didn't count, it wouldn't be too hard to buy steel tubing to stand up to pressure or corrosion, or any other conditions. Doing it economically is another thing. That's what the men above are making possible.

They're working with the hot tensile testing machine in The Timken Company's modern Metallurgical Research Center—testing steel under increasing loads (as high as 60 tons) at high temperature, until rupture occurs. It's just one way we pre-test steels to determine their performance in high temperature applications. Another assurance that you will get Timken® seamless steel pressure tubing having just the right analysis for your job. The one that will give you the best possible tube life per dollar.

When you buy Timken steel you get: *1) Quality that's uniform from heat to heat, tube to tube, order to order—targeted to your end use. 2) Service from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.*

Timken high temperature steel tubes are available in all stainless and alloy grades in sizes up to 11″ O.D. by 3¼″ wall. And Timken Company steel experts are always ready to help you select *the one* tube steel analysis that will give you *maximum tube life per dollar.* Call or write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

TIMKEN®
Fine Alloy STEEL

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

Men . . .

is succeeding **E. F. Sisson,** who has resigned after 32 years with Newport. Spitz has been executive vice president since early 1960. He has been with Newport Industries since 1946, when he joined in an engineering capacity.

Dr. P. R. Ryason has been promoted to senior research chemist, petroleum products research section, Richmond Laboratory, California Research Corp.

C. V. McKean has been promoted to staff engineer in the Technical Division, Baytown, Texas, refinery, Humble Oil & Refining Co.'s Humble Division. He handles project engineering assignments on basic equipment of the Operations Services Division, and coordinates efforts of Humble and contractors' personnel. McKean holds a B.S. degree in mechanical engineering from Rice University.

McKean

Norman Newton has been promoted to superintendent, Continental Oil Co.'s Wichita Falls refinery. He was formerly process superintendent at the Wichita Falls plant. Newton joined Conoco in 1925 and served briefly as a chemist at Artesia, N. M., before transferring to Wichita Falls in 1926. He was resident chemist at the Wichita Falls refinery for 12 years before his promotion to assistant superintendent in 1948 and process superintendent 10 years later.

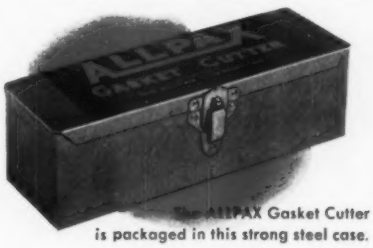
Newton

Dr. Eric Rau, Dr. Charles B. Hopkins, Jr., and Dr. John F. Jones, Jr., have been named to the Central Research Department, Food Machinery and Chemical Corp., Princeton, N. J. Dr. Rau will be working in the area of electrochemistry, Dr. Jones and Dr. Hopkins will be concerned with the FM coke project.

C. V. Sternling, a Shell Oil Co. engineer, and **L. E. Scriven,** of the University of Minnesota, have received the Allan P. Colburn Award from the American Institute of Chemical Engineers. The award was presented for a basic research program conducted in Shell Development Co.'s Emeryville, Calif., research center. This is the first Colburn Award honoring research in the

Cut Perfect Gaskets *Easily* with the ALLPAX Gasket Cutter

If you can draw circles with a compass you can cut perfect gaskets in seconds with this handy kit. Just set the blade for the desired thickness, set the pivot post at the desired diameter, and a smooth swing of the cutter gives you a clean, accurate gasket . . . from a ¼ inch bolt hole to a 60 inch outside cut. Larger diameters can be cut with additional extension arms.



The ALLPAX Gasket Cutter is packaged in this strong steel case.

The ALLPAX Gasket Cutter has become standard equipment in thousands of plants where expensive "down time" is kept at a minimum by cutting new gaskets when and where they are needed. Available in five styles to cut maximum diameters of 12, 24, 36, 48, 60 inches.

Use the following Allpax gasket materials for your gasket requirements:

400 —Compressed Asbestos Sheet
500 —Superheat Compressed Asbestos Sheet
600 —Vegetable Fiber Oil Proof Sheet
700 —Red Rubber Sheet
750 —Black Rubber Sheet
800 —Diaphragm Sheet
850 —Cloth-Inserted Sheet

ALLPAX
"The Packing that Packs All"

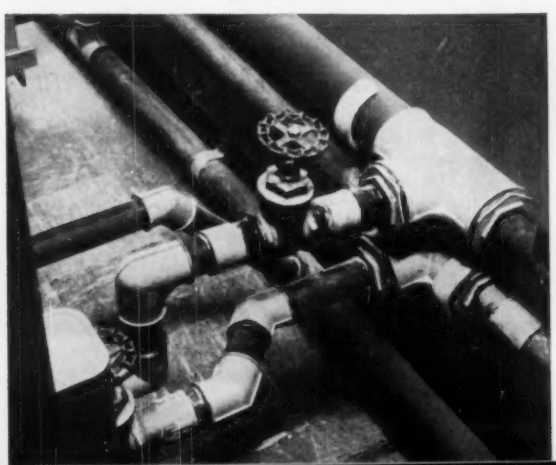
SEND FOR OUR NEW CATALOG — TODAY!

A complete line of packing, tools, gasket materials
Distributors in principal cities

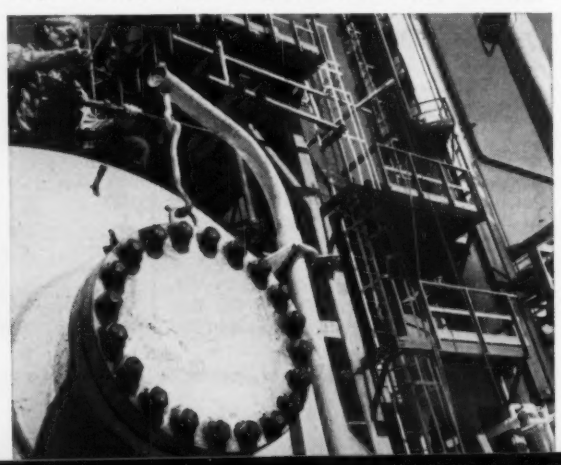
THE ALLPAX COMPANY, INC.
160 Jefferson Ave., Mamaroneck, N. Y.
CANADIAN DISTRIBUTORS: Albion Asbestos Packings Ltd., Montreal 8, Quebec

For more data on advertised products, use Readers' Service Cards, last page.

REPUBLIC SRK PLASTIC PIPE is extensively used to make up spray headers and bars in cooling towers. SRK resists corrosion and scale build-up. Tough, yet light in weight. Easy to handle. Eliminates heavy supports required with conventional piping. SRK is also widely used for carrying corrosive fluids and waste. Write for additional information.



REPUBLIC ALLOY STUDS are characterized by accurate, full-formed threads. Usually furnished in AISI 4120 Chrome-Moly Steel, heat treated to ASTM A-193, designation B-7, or in designations B-14 and B-15 for higher temperatures. Exceptionally high strength eliminates danger of creep, stretch, or fatigue-failure. Send coupon for booklet.



FARROWTESTED ELECTRUNITE

tubing in tune with today . . .

Today's high pressure operations demand special tubing with special requirements to meet critical day-in, day-out service—safely and economically. You can't afford to test the tube after it has been installed!

Get predictable, dependable service every time. Specify Republic ELECTRUNITE Heat Exchanger Tubing, in carbon or stainless steel, FARROWTESTED to your specifications.

FARROWTEST is Republic's exclusive non-destructive eddy-current test that probes for and detects injurious defects so small they pass ordinary internal fluid or gas pressure tests. FARROWTEST looks deep within the tube wall, is calibrated to reject tube with defects as shown in table below.

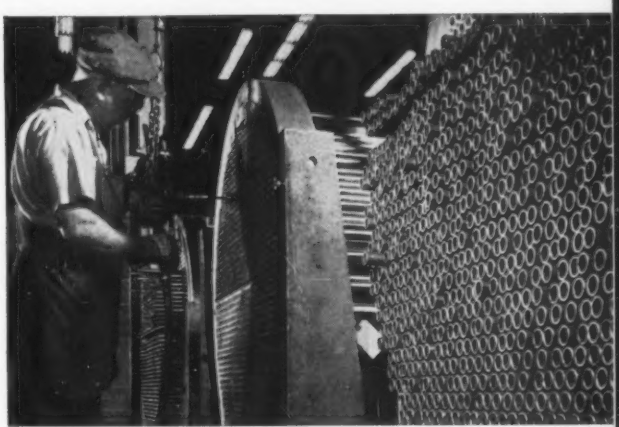
ELECTRUNITE carbon steel is produced to ASTM specification A-214; stainless steel to ASTM specification A-249. Both specifications include eddy-current requirements—FARROWTEST. And, Republic offers FARROWTEST as an alternative to other less positive tests at no increase in cost!

Your Republic representative can tell you more about the cost-saving advantages of ELECTRUNITE—FARROWTESTED for your protection. Call, or write today.

FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	.006″	.0025 sq. inches
18	.006″	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



FARROWTEST . . . BEST TEST YET! Not a laboratory theory, not a mere inspection tool, but an exclusive production line test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above.

REPUBLIC ELECTRUNITE STAINLESS STEEL HEAT EXCHANGER TUBING meets the rigid requirements of critical processing and refining operations. It rolls in easily, resists corrosion, protects the quality of the product. Specify ELECTRUNITE Stainless Steel Tubing for your next original or retubing operations.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

Strong, Modern, Dependable

REPUBLIC STEEL CORPORATION
DEPT. PR-1655
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:
☐ ELECTRUNITE® Carbon Steel Heat Exchanger Tubing
☐ ELECTRUNITE Stainless Steel Heat Exchanger Tubing
☐ FARROWTEST® ☐ Republic SRK Plastic Pipe
☐ Republic Alloy Studs Booklet

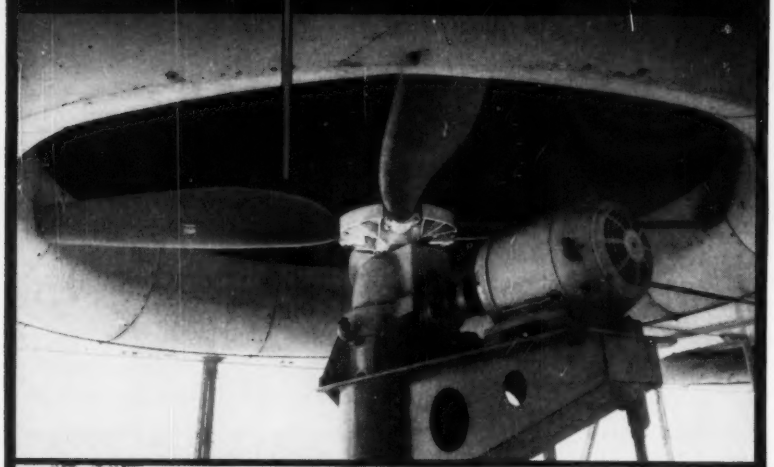
Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

HARTZELL Hollow Glass PLASTIC FAN BLADE



Hartzell Glass Plastic blades are being used in this forced draft heat exchanger operation at El Paso Natural Gas Company's Jal, New Mexico Plant #4. They are 10 feet in diameter and were installed December 22, 1958.

Provides More Efficient, Less Costly Installation, Cooling, Maintenance

• Lightweight (¼ that of standard plastic blade) yet unusually strong. This saves wear and maintenance on bearings, gears, shafts, support members . . . power consumption because it takes less horsepower to move large volumes of air. • Superior resistance to acids, corrosive material, abrasive and impingement effects. • Economical in forced and induced draft, wet and dry applications . . . cooling towers and heat exchangers. • Blades dynamically balanced to hub for quick easy installation and replacement in any Hartzell steel hub. • Design puts fan noise at a minimum. • No painting or finishing—color is in raw material. • Four and six blade assemblies.

Get All The Profit-Facts.
Write direct or call your nearby Hartzell Representative.

HARTZELL

Engineering Offices in Principal Cities

PROPELLER FAN CO.
Div. of Castle Hills Corp. Piqua, Ohio

Men . . .

petroleum industry, according to **F. J. Van Antwerpen,** institute secretary. He said that until 1960, the award has been granted only for research conducted in the chemical industry and in colleges and universities.

Burwell Spurlock has been promoted from group supervisor to engineering associate, petroleum process development section, Richmond Laboratory, California Research Corp. Spurlock joined the firm in 1935 after receiving an M.S. degree in chemical engineering from the University of Colorado.

Dr. Paul P. McClellan, 55, staff associate in research administration for Jefferson Chemical Co., Inc., died of a heart attack December 17. He had been with the company since 1945.

Test Yourself

(Answers to Quiz on Page 182)

CASE NO. 1

Arbitrator Byron R. Abernethy ruled: "There is no justification for what these employes did. Under normal circumstances their conduct was just cause for discharge. But their foreman warned them in advance that if they persisted in misconduct, they could expect punishment of three days' layoff. They had a right to rely on that warning, and the company was bound by it. Discharge was no longer justified. The two men are to be reinstated and paid for all time lost except the 3-day layoff."

CASE NO. 2

Arbitrator Ralph Roger Williams ruled: "The employes worked almost eight hours following their violation of the rule. Supervisory personnel were present with full authority to impose the three-day suspension and inform these men. When the grievants reported for work, it was not at that time 'due to their own fault' that they were not put to work. They were under a duty to report. The company is liable for reporting pay where such disciplined workers report for work in good faith. The company made no reasonable effort to notify the employes of their disciplinary suspension. The two men shall be paid for the four-hour reporting time."

CASE NO. 3

Arbitrator Charles S. LaCugna ruled: "The company does have the contractual right to determine what shall and what shall not be posted. This letter cannot be classified as 'data, notice, or bulletin.' The language and tone is caustic and intemperate. It praises and defends union activity and impugns the motives and actions of the company. The contract does NOT envision the use of union bulletin boards as a media for union organizational material."

For more data on advertised products, use Readers' Service Cards, last page.

CUT FUEL BILLS 20% WITH A LJUNGSTROM® AIR PREHEATER

The world's largest fluid catalytic cracker at Esso's Bayway Refinery is equipped with a new Ljungstrom Air Preheater. This picture shows the half-ton cold-end elements being installed in the Ljungstrom rotor.

Your biggest refinery operating expense is the money you burn: fuel costs. You can chop fuel bills ⅓ with a Ljungstrom Air Preheater, and here's how:

Your fuel bill drops about 1% for every 45-50°F you raise the temperature of combustion air. Ljungstroms now in service raise the air temperature 1000°F or more — and the rest is simple arithmetic. With a Ljungstrom, four barrels of fuel do the work of five. On fuel savings alone, one eastern refinery came up with net savings of $67,800 in the first year they used a Ljungstrom.

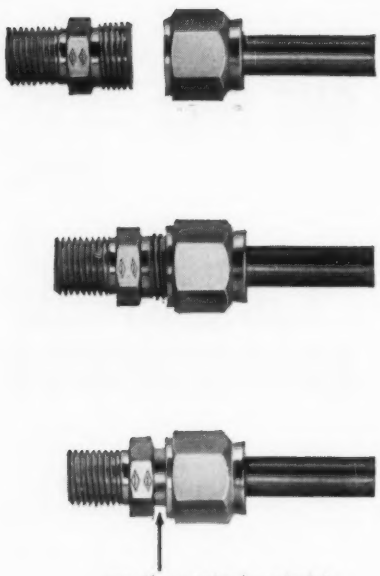
SAME FUEL, MORE HEAT. Ljungstrom economy is flexible economy. If total throughput is more important to you than fuel savings, a Ljungstrom can help boost the capacity of a pipe still at least 10% a day, without any increase in fuel consumption.

THESE ARE FACTS backed up by 25 years of Ljungstrom performance in refineries all over the world. But they're not the only facts. To find out about Ljungstrom's low-cost maintenance, easy inspection, in-service cleanability, space-saving compactness, call or write The Air Preheater Corporation for a free copy of a brochure called "The Ljungstrom Air Preheater for Process Equipment."

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

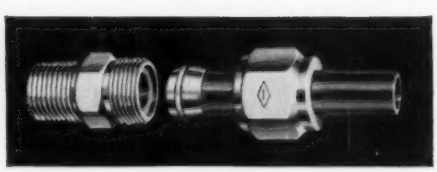
you can see see see when it's tight



With Hi-Seal you can *see* that hazards are not installed in your tubing system. When the threads no longer show, the connection is pressure-tight. No other fitting offers this advantage.

This means an easy, foolproof assembly that is inspected with just a glance. Anyone who can handle a wrench can make a dependable Hi-Seal joint every time. No need for assembler to count wrench turns. No over- or under-tightening to worry about.

Hi-Seal flareless assemblies are made faster, more economically, more surely. Specify Hi-Seal tube fittings.



BUTT JOINT **HI-SEAL**

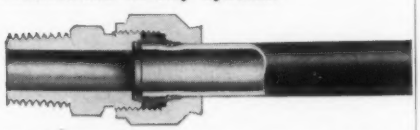
IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

see

many reasons why you're ahead with HI-SEAL®

Seeing when they're tight is only one reason for preferring Hi-Seal fittings. Of course, this is a big one for fast, positive inspection and for design engineers who want leakproof, foolproof connections in any system.



Withstand vibration, high pressure — Hi-Seal fittings provide firm tube support for excellent vibration resistance. The fitting is a grip type, rather than a bite type. Three serrations in the sleeve establish the grip without damaging or weakening the tube.
When assembled, Hi-Seal fittings give you a pressure-tight seal compatible with the tubing required. For extreme pressure ranges, Braze-Seal fittings give make and break flexibility.

Make and break 25 times — Simple assembly and re-assembly of Hi-Seal butt-joint fittings mean greater re-use. Hi-Seal's standard is 25 re-uses. The industry standard is 15—or 66⅔% more for Hi-Seal.

Close bends — Butt-joint H-Seal fittings make close bends possible. Reduce space, material by as much as a half!

One fitting for entire system — Hi-Seal is the most versatile fitting you can use. By standardizing on Hi-Seal, installation and maintenance men can plumb a job fast, yet perfectly, in any pressure range. Available in all styles and combinations, plus a variety of metals—steel, stainless steel, brass, aluminum, titanium, Monel, etc.

Now Imperial-Eastman meets *all* your fluid piping requirements—tube fittings, valves, couplings, flexible and rigid hydraulic lines, thermoplastic tubing, and tubing tools.

FITTINGS

IMPERIAL-EASTMAN

Suppliers Notes...

COOPER-BESSEMER CORP. has assigned **John O. Fighter** to the International Division sales office. Replacing Fighter as branch manager of the Anaco, Venezuela, office will be **W. R. Bohannan,** formerly a sales engineer at the corporation's Caracas, Venezuela, branch office. Fighter has been with Cooper-Bessemer since 1955.

Fighter

Bohannan

DANIEL ORIFICE FITTING CO. has appointed William B. Wickersham and Co., executive sales representative in New England. Wickersham will handle sales and service of Daniel products for flow measurement in Maine, New Hampshire, Vermont, Connecticut, Rhode Island and Massachusetts, except for Berkshire County.

ACF INDUSTRIES, INC., has entered into a licensing agreement for the manufacture of refinery fittings in Australia. The agreement is the latest in ACF's plans for expansion of its foreign operations.

TRETOLITE CO. OF CALIFORNIA, division of Petrolite Corp., has completed the move to its new offices and manufacturing plant at Brea, Calif., located at 200 South Puente St. The company's new 23-acre Brea site includes an administration building, three laboratory buildings, and a complete, highly automated chemical manufacturing plant.

COMPUTER SYSTEMS, INC., has appointed **Stanley H. Fried** to the applications research staff. Prior to joining Computer Systems, Fried served as assistant scientist at AVCO Research and Advanced Development Division.

DRESSER INDUSTRIES, INC., has formed a new division, Dresser Electronics, to include all the activity in the electronics field of two Dresser subsidiaries, Southwestern Industrial Electronics Co., Houston, and Hermetic Seal Transformer Division, Garland, Texas.

VITRO ENGINEERING CO. has elected **L. F. A. Mitchell** vice president of sales. Mitchell has been vice president and director of Burns and Roe, Inc., for the past eight years. He was previously general sales manager of Sperry Products, Inc., and division manager, apparatus group, for Canadian Westinghouse Co., Hamilton, Ont.

CONSOLIDATED SYSTEMS CORP. has appointed **Horace W. C. Rickert** manager of material and **Jack Conterno** purchasing agent. Rickert joined CSC in 1958 as senior buyer and became purchasing agent in January 1959. Conterno came to the firm in 1958 as a buyer.

SOLAR AIRCRAFT CO., a subsidiary of International Harvester Co., has elected **Paul A. Pitt** vice president, engineering. **Sumner Alpert** has been named manager, Solar's aerospace, ground support and industrial products, with responsibility for sales and project engineering in these areas.

STAUFFER CHEMICAL CO. has appointed **Wyman L. Taylor** Eastern sales manager, Industrial Chemicals Division. Taylor previously was administrative assistant to the vice president, sales.

ATLAS VALVE CO. has named Yost Industrial Sales, Seattle, Wash., sales representative for temperature, pressure and level controls. Yost will serve Washington, Idaho and all of Montana except for the extreme Southwest.

B-I-F INDUSTRIES, INC., has promoted **Charles J. Brex, Jr.,** and **Edward C. Ross** director of public relations and advertising manager, respectively. Brex was advertising manager since 1958, and Ross was assistant advertising manager.

UNITED STATES STEEL PRODUCTS DIVISION has elected **Loring S. Brock** president. Brock, who joined U.S. Steel in a shipping office at Los Angeles, succeeds **John Hauerwaas,** who has retired. Brock was executive vice president of the division prior to his present promotion.

DATEX CORP. has formed a servomechanism group. The new engineering unit will handle the design of precision servo systems, servo repeaters and special purpose analog computing equipment for industrial control applications. The group will be headed by **Delano Brouillette.**

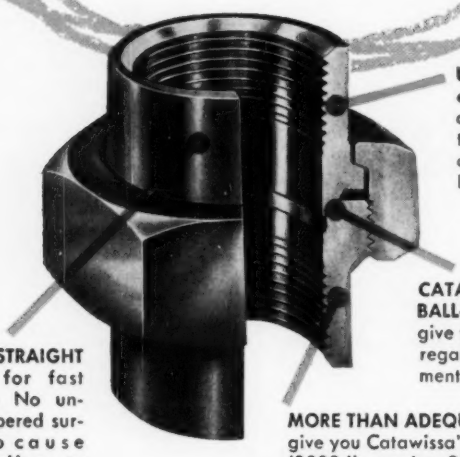
INSTRUMENT DEVELOPMENT LABORATORIES, INC., has named **Edward T. Connor** vice president. Connor will be in charge of expanding industrial and defense marketing activities of the company. He was formerly with General Electric Co. for about 10 years. He joined IDL's staff in September 1959.

WAIN-ROY CORP. has bought all the stock of A. C. Anderson, Inc. A. C. Anderson is a manufacturer of industrial hydraulic loaders, power crowd loaders, bulldozers, hydraulic roadside mowing machines and fire line plows.

NORTON CO.'s Refractories Division has assigned **James L. Miller,** refractories engineer in Chicago since 1954, to the San Francisco area. He will be succeeded in Chicago by **John A. Trogolo,** who has

For more data on advertised products, use Readers' Service Cards, last page.

only
CATAWISSA
gives you all these features for your forged steel pipe union requirements



UNIFORM WALLS for even expansion and contraction under temperature changes. THEY FOLLOW THE PIPE!

CATAWISSA BALL-TO-ANGLE SEATS give you a "Perfect Seal" regardless of pipe alignment!

ROUND, STRAIGHT BARRELS for fast wrenching. No uneven or tapered surfaces to cause wrench slips or wrench locking!

MORE THAN ADEQUATE wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

Catawissa Perfect Seal Pipe Unions are made by Union Specialists from 80,000-lb. tensile strength steel (ASTM Spec. A-105-55T, Grade II). Steel forgings from our own forging mill are closely checked for imperfections . . . and finishing on modern, automatic machines with close inspection during and after production give you pipe unions second to none!

Get your free copy of Catalog 60 showing the complete Catawissa line . . . write direct or stop at your favorite supply store.

CATAWISSA VALVE & FITTINGS COMPANY • CATAWISSA, PENNA.,

for complete, guaranteed pipe union satisfaction

. . . always specify
CATAWISSA

. . . at your favorite supply store

Suppliers . . .

been a product engineer, Norton plant, Worcester, Mass. **Robert T. Hale** has been appointed a refractories engineer in the Indianapolis area.

WOLVERINE TUBE DIVISION, Calumet & Hecla, Inc., has promoted **E. F. Hill** to director of new products and **R. M. Frink**

Hill

Frink

to director of contract planning. Hill held administrative and technical positions with Wyandotte Chemicals, Ethyl Corp. and Ford Motor Co. before joining Wolverine Tube in 1958 as market manager. Frink came to the firm in 1939.

FISCHER & PORTER CO. has named **Lawrence R. Greenhaus** general sales manager. **Reginald D. Schuler** has been appointed director of technology, and **Manuel J. Kauffman** has been named manager, Flowmeter Division. Greenhaus will handle sales of process instrumentation, chlorination equipment, data reduction systems, and laboratory glassware. Shuler will be in charge of engineering and research operations of the firm. Kauffman will coordinate sales of flowmeter lines, including rotameters, turbine meters and magnetic flowmeters.

Greenhaus

Schuler

Kauffman

CARPENTER STEEL CO.'s Alloy Tube Division has named **Thomas J. Bajoras** Pittsburgh, Pa., area salesman. Bajoras will handle sales of stainless and alloy tubing and pipe in Allegheny and surrounding counties in Western Pennsylvania, South-

For more data on advertised products, use Readers' Service Cards, last page.

HARSHAW
FLUORIDES

Boron Trifluoride
Hydrofluoric Acid
ANHYDROUS . . . AQUEOUS

The uses for Fluorides are ever increasing. Harshaw Fluoride production also has increased steadily. Shipments of cylinders and tank cars leave our plant daily. If required, you are invited to draw on the knowledge and experience of our staff of technical specialists on Fluorides.

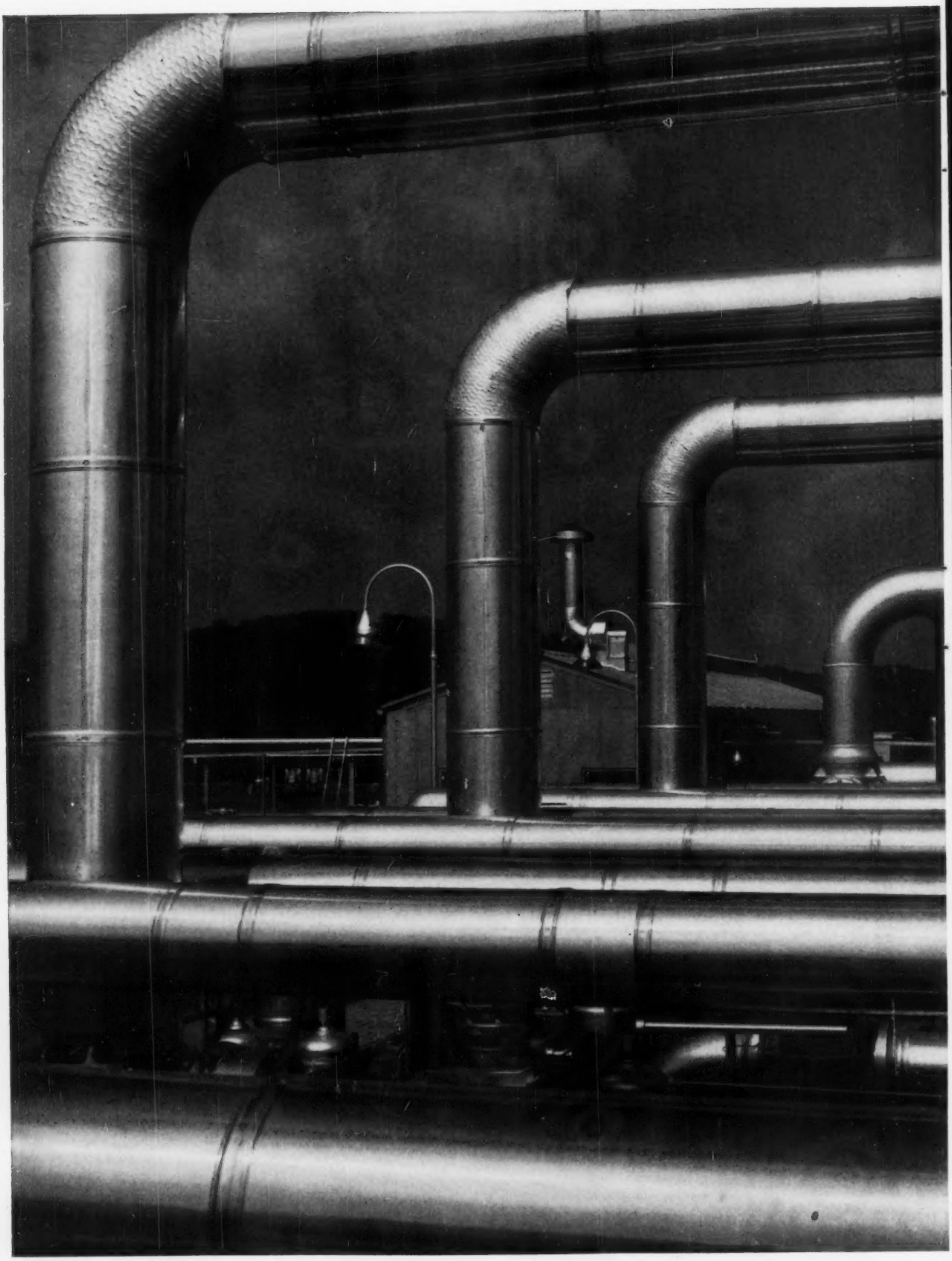
Write for your free copy of M.C.A. Chemical Safety Data Sheet SD-25 on properties and essential information about . . .
HYDROFLUORIC ACID
Anhydrous and Aqueous

THE HARSHAW CHEMICAL CO.
1945 EAST 97th STREET • CLEVELAND 6, OHIO
Chicago • Cincinnati • Cleveland • Detroit
Hastings-On-Hudson, N. Y. • Houston
Los Angeles • Philadelphia • Pittsburgh

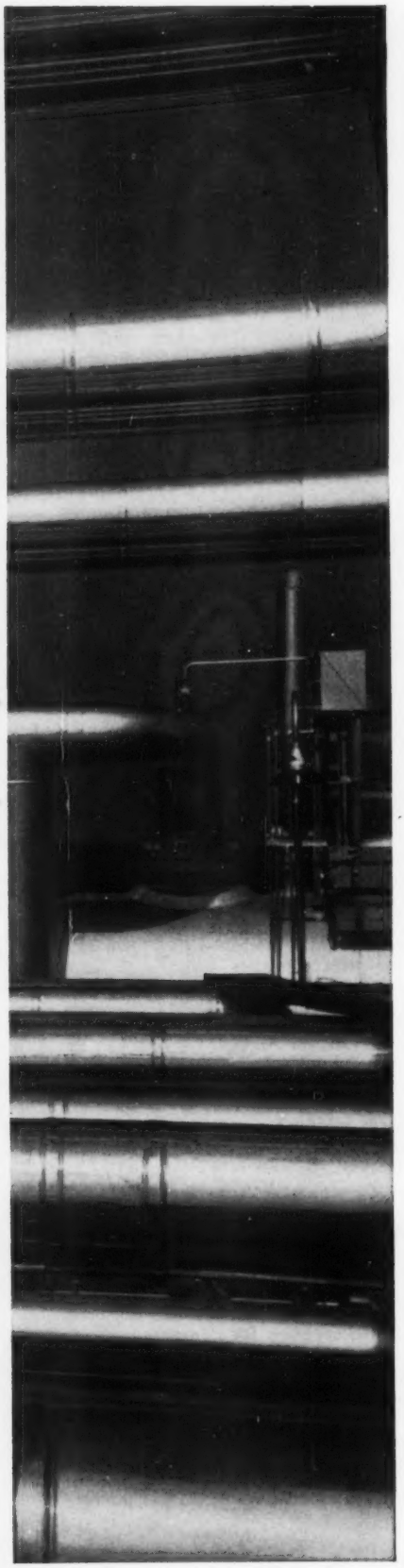
Here is a helpful list of HARSHAW high-quality fluorides:

Ammonium Bifluoride
Ammonium Fluoborate
Barium Fluoride
Bismuth Fluoride
Boron Trifluoride Complexes
Chromium Fluoride
Copper Fluoborate
Fluoboric Acid
Fluorinating Agents
Frosting Mixtures
Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
Hydrofluosilicic Acid
Laboratory Fluorine Cells
Lead Fluoborate
Lithium Fluoride
Metallic Fluoborates
Potassium Bifluoride
Potassium Chromium Fluoride
Potassium Fluoborate
Potassium Fluoride
Potassium Titanium Fluoride
Silico Fluorides
Silicon Tetrafluoride
Sodium Fluoborate
Tin Fluoborate
Zinc Fluoborate
Zinc Fluoride

HARSHAW



PHOTOGRAPHED AT NEW YORK STATE NATURAL GAS CORPORATION'S LEIDY COMPRESSOR STATION, TAMARACK, PA.



Installation time at Leidy Station cut 25% with prejacketed J-M METAL-ON® pipe insulation!

"ALMOST 2 MILES OF METAL-ON PROTECTS OUR OUTDOOR PIPELINES. THIS IS THE BEST–AND BEST-LOOKING–INSULATING JOB I'VE EVER SEEN,"
says head station engineer VICTOR CUMMINGS

Leidy Pool, with an ultimate storage capacity of 105.6-billion cubic feet of natural gas, is served by a compressor station incorporating almost two miles of outdoor pipelines. Both lines and equipment must be completely protected against northern Pennsylvania's violent winter storms, torrential spring rains and summer heat. Metal-On jacketing, developed by J-M, was chosen to handle this difficult job.

Metal-On is prefabricated at the factory in 36-inch lengths. Each length combines high-temperature J-M Thermobestos insulation . . . a moisture barrier . . . and a special aluminum alloy jacket. And because each length can be applied in one simple operation, erection time savings at Leidy averaged 25%! Metal-On can also be easily cut on the job with portable power or hand saws. Cut-outs for hangers and supports are simple to make.

Maintenance savings can be very impressive, too. Metal-On doesn't corrode, needs no painting. The rugged jacketing, combined with a locking device that snaps closed and seals joints, will lock out weather and moisture permanently. And each section can be easily removed for trouble-shooting.

You may not have *two miles* of pipeline . . . but if you have a tough outdoor insulation problem, it will pay you to investigate J-M Metal-On. Just write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

METAL-ON:
JUST MINUTES FROM CARTON TO PIPE!

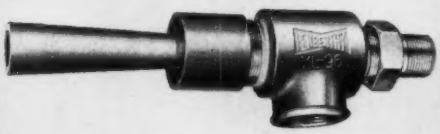
JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

JOHNS MANVILLE JM PRODUCTS

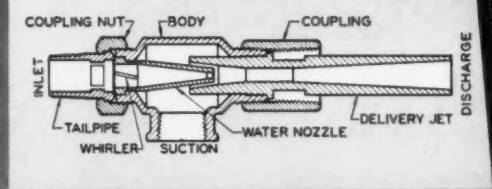
For more data on advertised products, use Readers' Service Cards, last page.

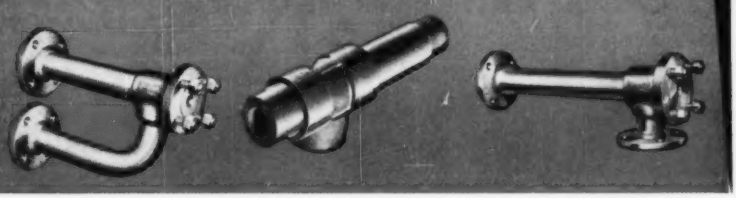
AVAILABILITY



From leading distributors coast-to-coast

JET PUMPS BY PENBERTHY





When you want something . . . like a jet pump, for example . . . you *want* it. Not day after tomorrow, or next week, but *now!* Right? And that's just one more advantage of Jet Pumps by Penberthy. Availability . . . *now*.

Penberthy, to begin with, has a broader line with more models and sizes to offer . . . hydraulic, air or steam operated . . . in bronze, iron, stainless steel, monel, plastic and other materials. Penberthy, in addition, offers "standards" on many designs that would be labeled "special" by other manufacturers.

Add to the above, Penberthy's nationwide network of representatives and stocking distributors. They're located in all the major metropolitan areas so, chances are, there's a Penberthy man near you. Be happy to supply his name and address . . . write or call the Penberthy sales office at the address below . . .

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

PENBERTHY
Dedicated to Quality Since 1886

GENTLEMEN: Would like more information.
Please send your Jet Pump Catalog #512R.

NAME_____ TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

Suppliers . . .

eastern Ohio, Northwest Maryland, most of West Virginia and Eastern Kentucky.

BAGWELL CO. has appointed **Thomas L. Irwin** inside sales engineer. Before joining Bagwell, Irwin was with the Engineering Department, Douglas Aircraft Co.; Cornett, Wood & Associates, Consulting Engineers; and Associated Expressway Engineers, Inc. Bagwell, manufacturers' representative of equipment for refineries, chemical plants and industrial firms, serves Oklahoma, Kansas, Arkansas and the Panhandle of Texas.

Irwin

CHEMETRON CORP. has promoted **Chester L. Pedigo** to engineering consultant, Chemical Products Division. Pedigo will coordinate plant engineering, material handling and new construction functions. He has been with the corporation 10 years and had been Girdler Catalysts' plant manager since 1957.

ROCKWELL MANUFACTURING CO.'s Meter & Valve Division has named **James H. Sells** district manager in the Houston area. Sells joined Rockwell as a sales engineer and worked in the Houston and New Orleans areas until 1956 when he was appointed San Francisco district sales manager for the Municipal & Utility Division. He was promoted to his most recent position in 1959. He attended Texas A & M College.

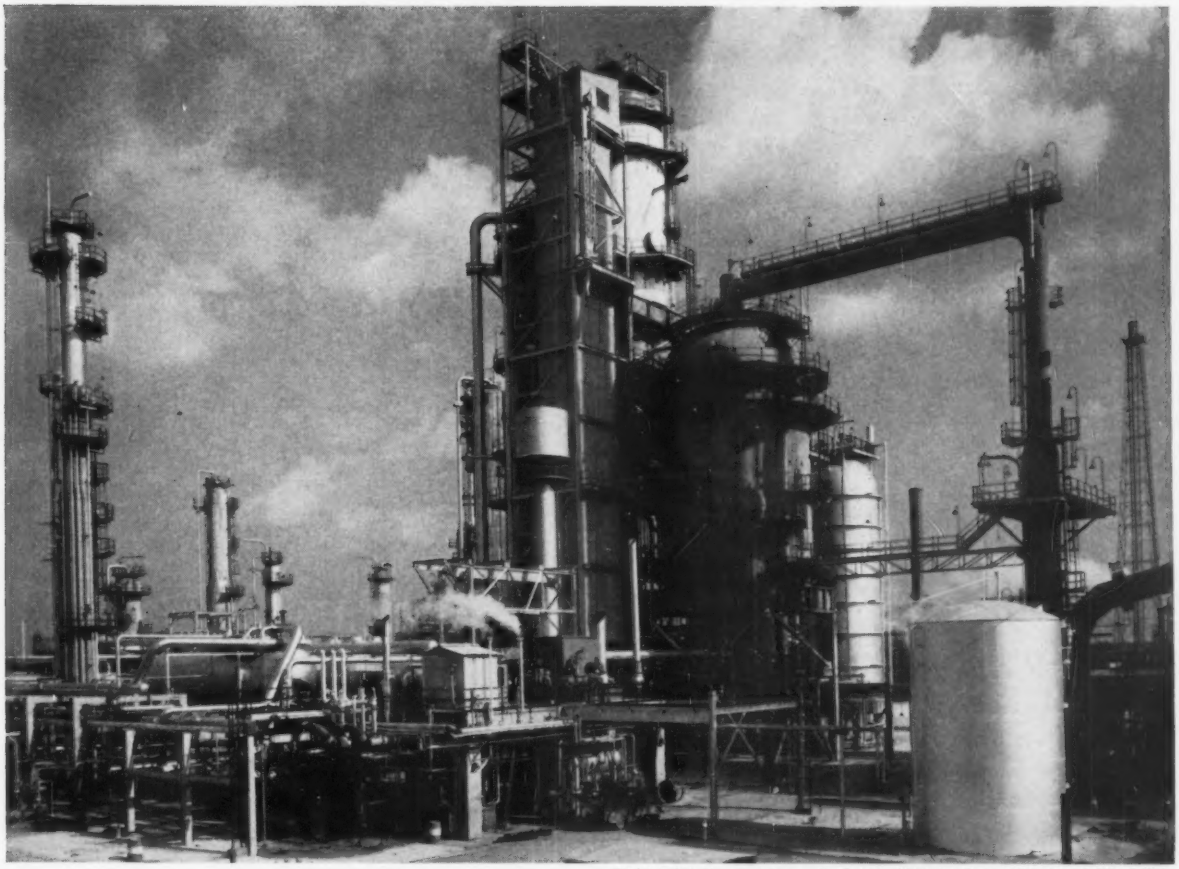
Sells

KAISER STEEL CORP. has appointed **P. T. Bloodsworth** Eastern sales manager. He will head the company's sales office at 300 Park Ave., New York City.

CHICAGO BRIDGE & IRON CO. has named **William M. Freeman** sales manager in the New York district. Freeman was manager of CB&I's process equipment sales group for two years. He has been with the company for 19 years.

ARMOUR INDUSTRIAL CHEMICAL CO. has named **John W. Anthony** sales representative in Dallas, Texas. Anthony was formerly a consultant with a corrosion engineering firm and prior to that worked for Magnolia Petroleum Co. coordinating corrosion control in oil and gas production.

OAKITE PRODUCTS, INC., has appointed **Paul R. Bower, Jr., Robert D. Casey** and



Fluid catalytic cracking unit, Toledo (Ohio) refinery, Standard Oil of Ohio

Refractory insulating concrete stops corrosion in this new FCC

In constructing the fluid catalytic cracking unit at Sohio's new Toledo refinery, corrosion resistance, abrasion resistance and insulation were built in right from the start. Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, was used to line the regenerator, cyclones, stripper, catalyst and reactor transfer lines. Now on stream, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines... resist attack by acid condensate... and provide insulation at high temperatures.

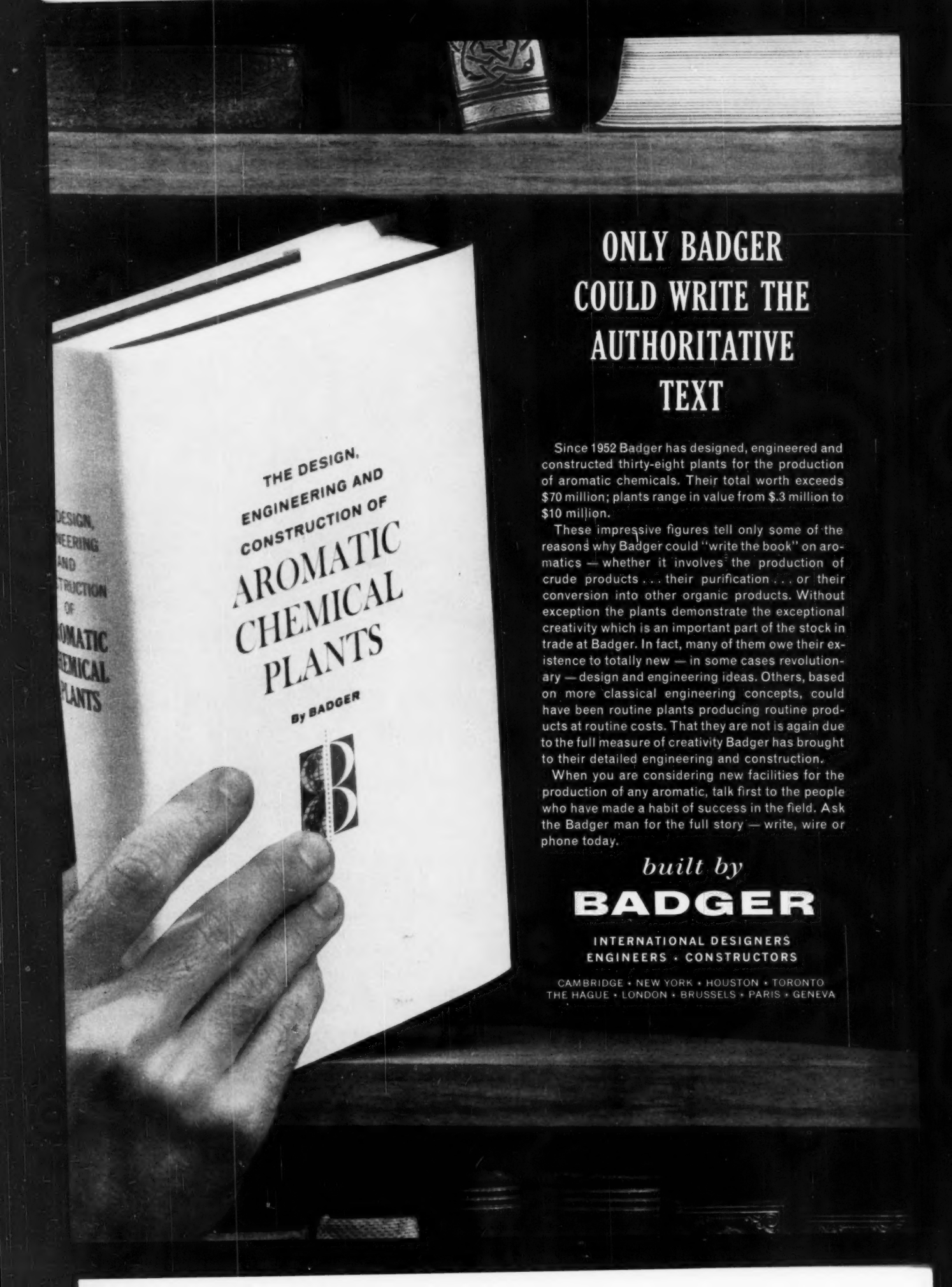
Installation of monolithic concrete linings is fast, easy, economical – whether cast in place, gunited or plastered. Concrete reaches service strength in 24 hours.

For added convenience, castables bonded with LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

"USS," "Atlas" and "Lumnite" are registered trademarks L-195

Universal Atlas Cement
Division of
United States Steel

OFFICES: Albany • Birmingham • Boston • Chicago • Dayton • Kansas City • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • St. Louis • Waco



ONLY BADGER COULD WRITE THE AUTHORITATIVE TEXT

Since 1952 Badger has designed, engineered and constructed thirty-eight plants for the production of aromatic chemicals. Their total worth exceeds $70 million; plants range in value from $.3 million to $10 million.

These impressive figures tell only some of the reasons why Badger could "write the book" on aromatics — whether it involves the production of crude products . . . their purification . . . or their conversion into other organic products. Without exception the plants demonstrate the exceptional creativity which is an important part of the stock in trade at Badger. In fact, many of them owe their existence to totally new — in some cases revolutionary — design and engineering ideas. Others, based on more classical engineering concepts, could have been routine plants producing routine products at routine costs. That they are not is again due to the full measure of creativity Badger has brought to their detailed engineering and construction.

When you are considering new facilities for the production of any aromatic, talk first to the people who have made a habit of success in the field. Ask the Badger man for the full story — write, wire or phone today.

built by

BADGER

INTERNATIONAL DESIGNERS
ENGINEERS · CONSTRUCTORS

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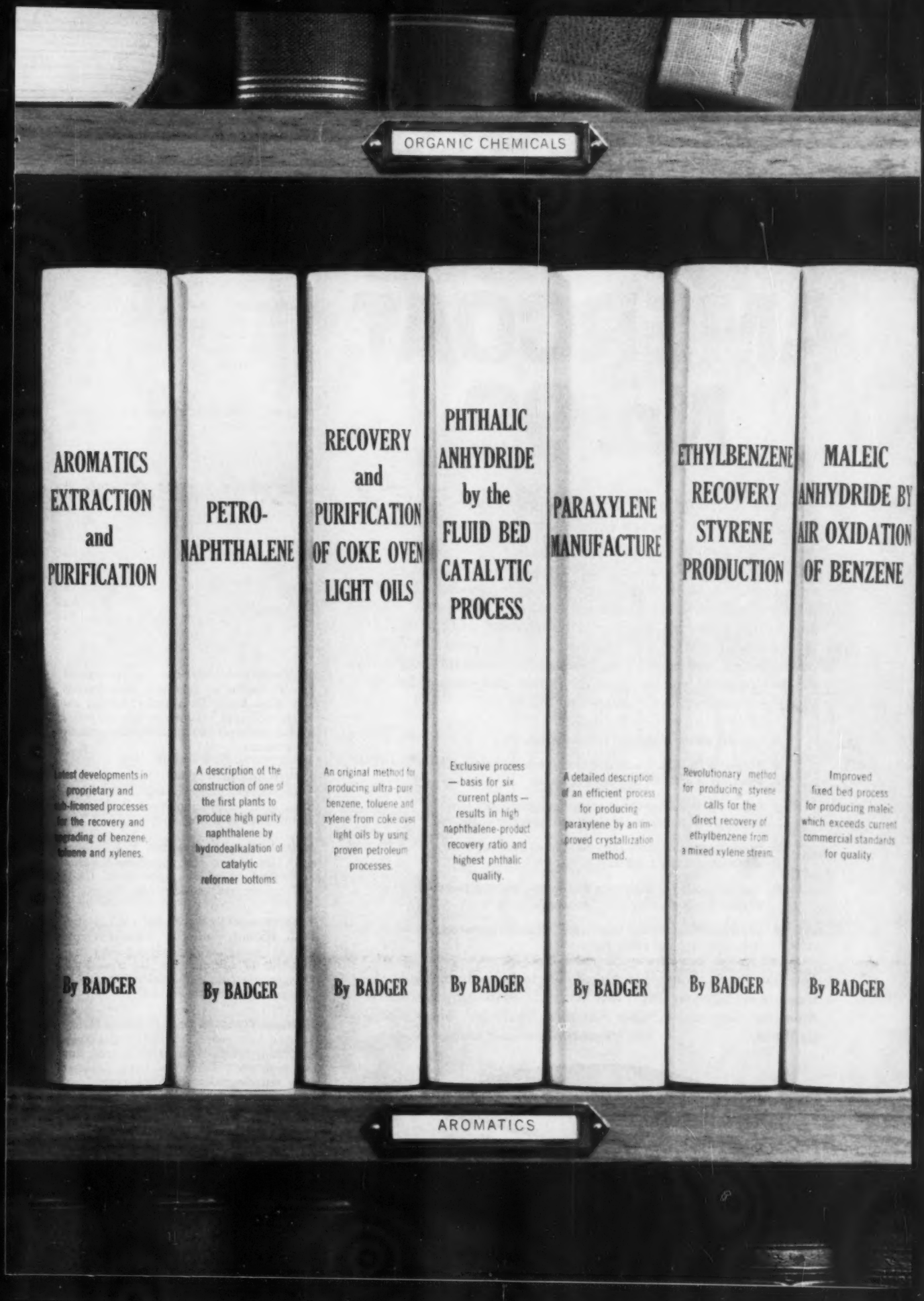

ORGANIC CHEMICALS
AROMATICS EXTRACTION and PURIFICATION
Latest developments in proprietary and sub-licensed processes for the recovery and upgrading of benzene, toluene and xylenes.
By BADGER
PETRO-NAPHTHALENE
A description of the construction of one of the first plants to produce high purity naphthalene by hydrodealkalation of catalytic reformer bottoms.
By BADGER
RECOVERY and PURIFICATION OF COKE OVEN LIGHT OILS
An original method for producing ultra-pure benzene, toluene and xylene from coke oven light oils by using proven petroleum processes.
By BADGER
PHTHALIC ANHYDRIDE by the FLUID BED CATALYTIC PROCESS
Exclusive process — basis for six current plants — results in high naphthalene-product recovery ratio and highest phthalic quality.
By BADGER
PARAXYLENE MANUFACTURE
A detailed description of an efficient process for producing paraxylene by an improved crystallization method.
By BADGER
ETHYLBENZENE RECOVERY STYRENE PRODUCTION
Revolutionary method for producing styrene calls for the direct recovery of ethylbenzene from a mixed xylene stream.
By BADGER
MALEIC ANHYDRIDE BY AIR OXIDATION OF BENZENE
Improved fixed bed process for producing maleic which exceeds current commercial standards for quality.
By BADGER
AROMATICS

Biggest News in Protective Coatings Since 1942...

AMERCOAT No. 99

Amercoat No. 99 offers the time tested protection of vinyl coatings plus virtually foolproof application with cost reductions of up to 42%!*

For application with either airless spray or conventional spray equipment, No. 99 is a companion coating to Amercoat No. 33, the *first* practical vinyl maintenance coating. Introduced in 1942, No. 33 is . . . after 18 years . . . still protecting more than 200 million square feet of steel structures in the severest corrosive environments. And now, through exclusive Amercoat technological developments, you can have the proven protection of No. 33 PLUS the cost-cutting advantages of No. 99.

- Highest solids content of non-mastic vinyls
- Applied by airless spray, one cross sprayed coat easily produces a dry film thickness of 6 mils
- Applied with conventional spray equipment, dry film thickness of 5 mils is obtained with just two coats
- Labor savings of more than 50% have been reported, with material costs cut 35%
- Can be applied directly over Dimetcote, giving a two coat system unequalled by any comparable system
- Recommended for use on all types of structural steel, tank exteriors and ships' hulls

You may obtain complete technical data including a cost analysis showing savings you can realize with this coating by writing to Amercoat Corporation, 4809 Firestone Boulevard, South Gate, California.

**Documented user report furnished on request*

Amercoat® CORPORATION

126A

Dept. VM, 4809 Firestone Blvd., South Gate, California

921 Pitner Ave. Evanston, Ill. | 360 Carnegie Ave. Kenilworth, N.J. | 111 Colgate Buffalo, N.Y. | 2404 Dennis St. Jacksonville, Fla. | 6530 Supply Row Houston, Tex.

Suppliers . . .

Michael D. Juliana technical service representatives. Bower has been assigned to Akron, Ohio. Casey will represent the company in Arizona. Juliana has been placed in the Charleston, W. Va., territory.

THE B. F. GOODRICH CO. has named **George R. Wertz, Jr.,** Chicago district manager, B. F. Goodrich Industrial Products Co. Wertz was Minneapolis district manager. He joined the company in 1936 in production control.

PERKIN-ELMER CORP. has appointed **Edward B. Delany** product line manager of process control, Industrial Division. Delany was engineering group leader in process control for P-E's Instrument Division.

ROCKWELL MANUFACTURING CO.'s Meter & Valve Division has elected **Roy R. Bush,** Midwestern regional manager, sales vice president. Bush joined Rockwell in 1934 as a sales engineer. Since then he has served as Tulsa district manager, assistant product manager for valve sales, and since 1954, in his most recent position as Midwestern regional manager. He attended Oklahoma University.

Bush

CONTINENTAL-EMSCO CO. has promoted **Joe T. Gailus** to manager, non ferrous pipe sales. **Leslie D. Murphy,** former assistant manager, oil country tubular sales, is now manager Tubular Administration Department.

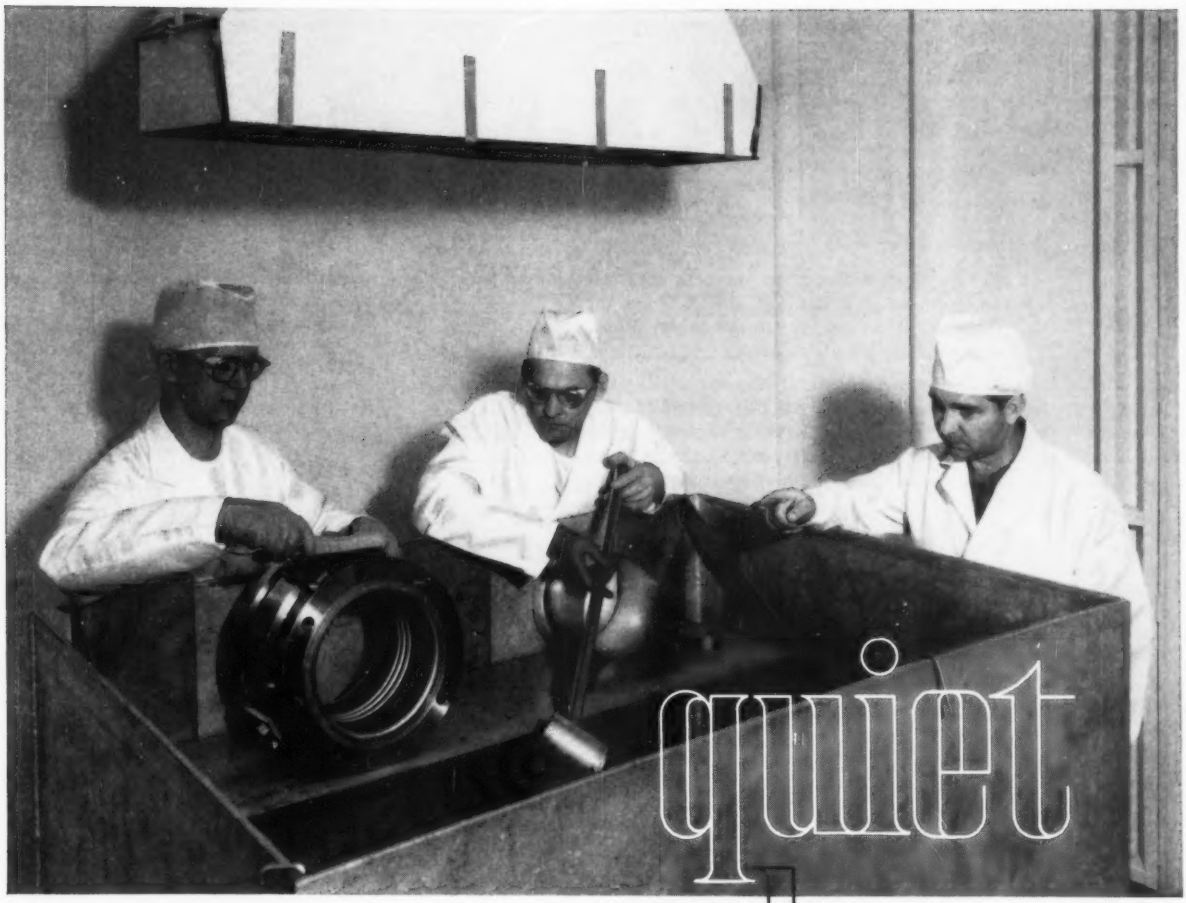
PARKER-HANNIFIN CORP. has appointed Arkansas Equipment Co., Inc., Little Rock Ark., a distributor of Parker hydraulic hose and hose fittings.

REPUBLIC RUBBER DIVISION, Lee Rubber and Tire Corp., has appointed **Charles E. Craft** field sales representative. Craft will headquarter in Midland, Texas.

RAYBESTOS-MANHATTAN, INC., has elected **R. B. Hazard,** a director. Hazard started with the company in 1945 as sales representative at Minneapolis. He was made vice president and sales manager, rubber and packings, in June 1956.

ACHESON COLLOIDS CO. has named **Henry J. Lang** sales representative for the Western Pennsylvania-West Virginia area. For the past year, Lang has been Acheson sales representative for Michigan.

CRANE CO. has appointed **William E. Gleason** comptroller, industrial products group. Before joining Crane, Gleason served in a similar capacity at the Hemp Division, American Thermos Products Co.



quiet please

Men in white clean and sterilize Adsco Expansion Joints with steam and detergents, dry, and hermetically seal them in polyethylene bags. At an Air Force Titan missile base, system contamination is less than 25 parts per million, with no particle larger than 150 microns.

Cleanliness of this magnitude reveals the slightest imperfection. The construction of these expansion joints which glisten like diamonds is revealed as not just good, but perfect; one slip could bring disaster.

When special designs and/or services with quality workmanship and dependability are required... call on Adsco.

ADSCO EXPANSION JOINTS BEING SCRUPULOUSLY CLEANED BEFORE OPERATION

ADSCO DIVISION

20 MILBURN STREET
BUFFALO 12, NEW YORK

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

For more data on advertised products, use Readers' Service Cards, last page.

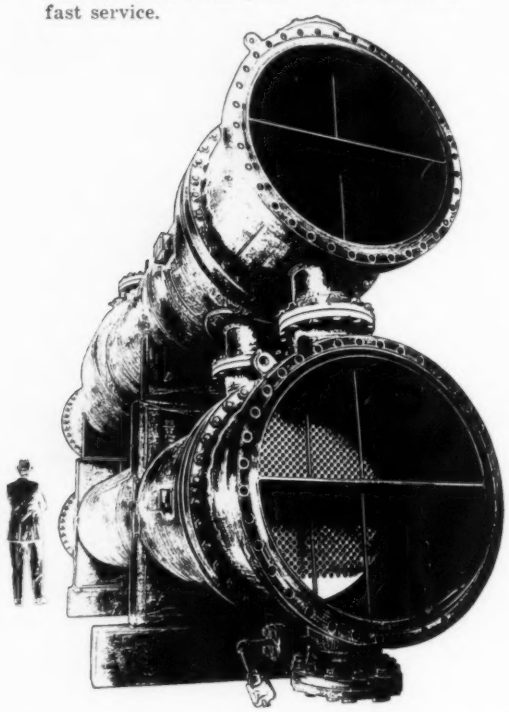
SWECO'S ONE MAN PLAN

Process equipment purchasing is an intricate undertaking . . . that's why SWECO assigns *ONE MAN* as sales engineer to coordinate and expedite your project.

He communicates your equipment rating and performance data to SWECO's staff of engineering specialists. Experts in meeting the challenges of new extremes in temperature and pressure, they develop improved designs and methods for most efficient and economical operation of process equipment.

He draws upon SWECO's 40 years experience in fabricating heat exchangers, pressure vessels and steam jet ejectors, from a wide range of metals and alloys. SWECO's know-how pays off for you in high-quality standards and reasonable production costs.

Your equipment is the responsibility of your SWECO project coordinator from design and production, until units are installed and operating to your satisfaction. He *knows* your project, gives you straight answers, fast service.



For details on SWECO heat exchangers, pressure vessels, steam jet ejectors and other equipment, write for Bulletin 16-333.

SWECO

Southwestern Engineering Company

4800 Santa Fe Avenue, Los Angeles 58, California

ENGINEERS — CONSTRUCTORS — MANUFACTURERS

INDUSTRY QUIZ

(Answers to Quiz on Page 21)

1. True. Standard of Ohio has found it so in their No. 1 refinery. "How You Can Start Daily Maintenance Scheduling," beginning on Page 106, gives a very detailed step-wise procedure of their system.

2. No. 3. There is no simple formula to measure maintenance performance—but by making a searching analysis of a wide variety of factors governing it, you can arrive at an index. So says the article "Can You Measure Maintenance Performance," Page 123. Checklists are included which will start the analysis for you.

3. No. 3. Prevention of *all* injuries is the optimum safety goal at Du Pont, according to "Is Maintenance Safety Out of Hand?," Page 129.

4. False. For the facts and figures, don't miss "Forecast for More Alkylation Capacity," Page 209.

5. False. Sandblasting creates no fire hazard if the sand pot, hoze, nozzle and operator are properly grounded to prevent buildup of static electricity. Also, sandblasting sparks are not dangerous because they are not hot enough to ignite flammable vapors. So says "Tanks Can Be Sandblasted In Service," Page 135.

6. True. This is one of the major advantages of using a welding machine for field stress relieving, according to the article "A New Look at Stress Relieving Field Welds," Page 139.

7. No. 3. It costs 42 percent less to properly use the airless spray techniques available today to apply vinyl coating, according to "Airless Spraying Vinyl Cuts Costs 42 percent," Page 143.

8. Yes, if they are the low-finned type. Get more details on a computer program in "Rate Exchangers This Computer Way," Page 147.

9. 80 percent of the installed synthetic ammonia capacity was used to supply the 1960 demand. For more data on production of many other petrochemicals, as well as predictions for future growth, see "Petrochemical Outlook Bright for '61," Page 161.

10. False. But evaporatively cooled exchangers will usually be better below 150° F, according to "Now Consider Evaporative Cooling," Page 165.

11. No.'s 1, 2 and 5. The other two shortcomings revealed by this survey were "*lack*" of contact with important groups outside the firm" and "inadequate personal inspection," says "Portrait of the Chief Executive," Page 173.

12. True. The separator had been washed by caustic soda. An analysis of the wash water showed almost no organic material in No. 2 separator. But it is very likely there *was* some in No. 1, according to "This Ammonia Unit Exploded," Page 178.

Petroleum Refiner Classified Ads

RATES: Regular Classified (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston 1, Texas.

HELP WANTED

DISTILLATION ENGINEER

Excellent opportunity for a Chemical Engineer with a new Petro-chemical Company located in the Ohio-Valley, to be in charge of distillation units. Four to five years experience desired. Salary open. Substantial employee benefits. Contact:

NOVAMONT CORPORATION
P. O. Box 189 Kenova, West Virginia

PROCESS ENGINEERS

McKee of Cleveland, Ohio offers permanent career opportunities with a rapidly expanding professional organization. Individuals possessing a minimum of 10 years experience in the design of petroleum, petro-chemical or general chemical producing facilities will be afforded unlimited advancement opportunities.

Reply in confidence to:
G. VICTOR HOPKINS
Arthur G. McKee & Company
2300 Chester Ave., Cleveland 1, Ohio

METALLURGICAL ENGINEER

The Chemstrand Corporation's nylon manufacturing plant at Pensacola, Florida is seeking a graduate engineer to assist the chief metallurgist in shop problems related to materials selection, welding and heat treatment. Experience with chemical processing equipment desired.

Excellent working conditions and benefit programs. Attractive community life and living conditions in Gulf Coast location.

Send resume of academic training and experience to:

Manager, Employment-Recruitment
Box P4
The Chemstrand Corporation
Decatur, Alabama

Refinery Operating Supervisors

For immediate employment. Job requires proof of U.S. citizenship, 3 to 5 years HCC or TCC experience at responsible level. No helpers or trainees desired. These are SUPERVISORY jobs ONLY and salaries are commensurate.

If interested and qualified, write

COMMONWEALTH OIL REFINING COMPANY, INC.
P. O. Box 1406
PONCE, PUERTO RICO

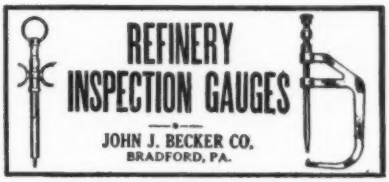
HELP WANTED

■ REFINERY SUPERINTENDENT—Independent integrated Oil Company needs Superintendent for expanding small established refinery located in small town in the Middle West. Reply to Box 345-R. Petroleum Refiner, Houston, Texas.

MISCELLANEOUS

■ IMPORT QUOTA—We seek Coastal Refiner wanting 1961 quota available now on contract. Bonus $1.10 level. Box 4803; Midland, Texas.

FOR SALE



AVAILABLE FOR SALE

Colorado Oil Shale

Crushed to minus 8-inch

Write: Commercial Development Division
Union Oil Company of California
P. O. Box 76
Brea, California

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For a free copy of our book catalog write to BOOK DEPARTMENT, GULF PUBLISHING COMPANY, P. O. Box 2608, Houston 1, Texas.

IF YOU HAVE THREADED FITTINGS

YOU NEED
LED-PLATE
ANTI-SEIZE SEALING COMPOUND

ASSEMBLY
MAINTENANCE
PRODUCTION

HIGH TEMPERATURE ANTI-SEIZE
No heat freeze. Temp. range -350° F to +2987° F
MEETS GOVERNMENT SPECIFICATIONS
Mil-A-907 QPL-907

NO GALLING OR SEIZING recommended for aluminum, stainless, titanium, plastic, steel, brass, etc.
HIGH PRESSURE SEALANT a real thread sealer, pressures held to 50,000 psi hydraulic fluids, 3500 psi air, 1000 psi gases. Has UL approval. For gases, steam, air, ammonia, hydraulic fluids.
CORROSION PROTECTION no corrosion weld, prevents rusting, acid-etch, etc.

SPECIFICATION COMPOUNDS IN STOCK

JAN-A-669 | SPEC. OXYGEN SEAL
MIL-T-5544 | NAVORD OSTD-53
MIL-A-13881 | CUSTOM COMPOUNDING

SEND FOR **FREE SAMPLE!**

APPROVED for Butane, Propane, Gasoline, Petroleum Oils.

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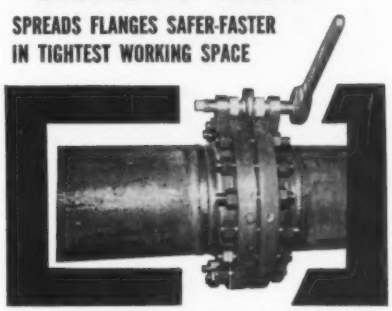
6609 Broad St., Los Angeles 1, Calif. U.S.A.

"SAFETY BOY"

SPREADS FLANGES SAFER-FASTER IN TIGHTEST WORKING SPACE



- Eliminates plant safety hazards and costly down time.
- Spreads all Series pipe flanges. Spreads ring joint flanges.
- Lightweight / Priced right

FOR CATALOG SHEET: WRITE TO
Wm. L. Riggs Co.
600 S. 129 E. Ave., Tulsa, Oklahoma

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
We sell direct to you.

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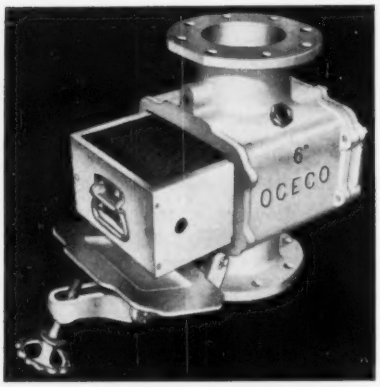
New Equipment & Literature...

as selected by Frank L. Evans, Jr., Maintenance & Design Editor

Dehydrators Remove Storage Tank Moisture

New dehydrators remove the moisture from air taken into storage tanks, as the product is being pumped out, thus preventing dilution and possible



contamination of tank contents.

The desiccant material is held in a basket-like drawer with wire mesh top and bottom, that slides into a gas-tight housing. Air being drawn into the tank, as product is being pumped out, passes through the desiccant mass and gives up its moisture. The moisture is adsorbed mostly into the pores of the desiccant material, consequently the flow efficiency of the vacuum relief system is practically unaffected.

A layer of "indicator material" on top of the basket-like drawer, and easily seen through the peep glass, turns from blue when dry, to pink, and then to white when saturated with moisture, so inspection and maintenance men will know when to replace the drawer of saturated desiccant with a drawer of dried and reactivated material.

Average life of a drawer of desiccant between reactivations, ranges from 30 to 100 days depending upon the humidity or dryness of the air, and the activity of the tank, i.e., the frequency of filling and pumping product out. Available in 2, 3, 4, 6, 8, 10 and 12-inch sizes the drawer is mounted easily between the roof collar and vacuum relief vent. The Johnston & Jennings Co.

Circle E1 green card, last page

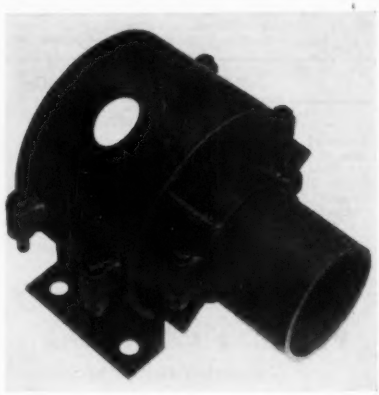
Guide Supports and Aligns Expansion Joint Piping

A full size range of carbon steel pipe guides for aligning and supporting piping in which bellows expansion joints and expansion compensators are used consists of a guide spider, to be clamped around the pipe whose movement is being controlled, and a guide casing, which can be bolted to a base or other supporting structures at any angle.

The pipe guides are available in two standard models, Series A for up to 1½-inch insulation and Series B for up to 2-inch insulation, from ¾ to 30-inch pipe size. Guides for greater insulation thickness can also be supplied.

Both series provide for 6 inches of axial movement and are readily adapted to greater traverse by increasing the length of the spider to equal the pipe movement. Guide casings are 3 inches long for pipe sizes 2½ inches and smaller, and 6 inches long for sizes 3 inches and larger.

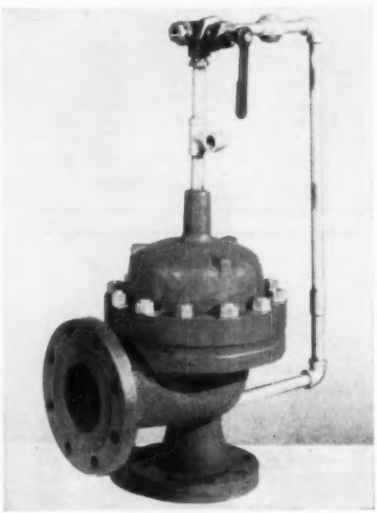
Pipe guides, essential to satisfactory performance of axial movement expansion joints, control the amount of lateral offset and angular rotation to which expansion joints are subjected by changes in pressure and pipe movement, and at intermediate locations, restrict the bowing of the line resulting from end load, the company said. The guides perform a dual function as pipe supports. Tube Turns.



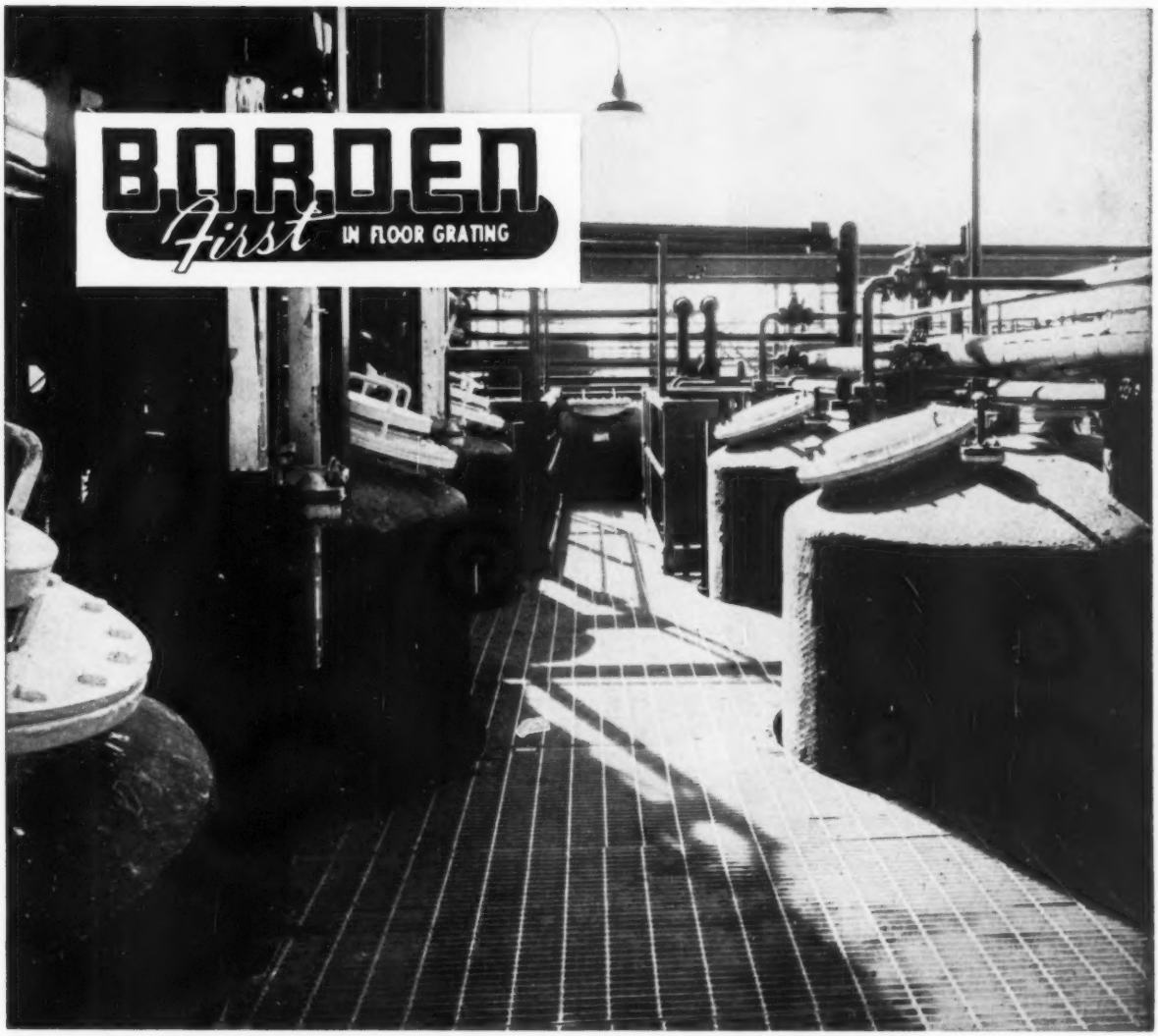
Circle E2 green card, last page

Fail-Safe Safety Valve Protects Product Vessels

A new depressuring safety valve is a completely "fail-safe," high-pressure valve designed to meet requirements for depressuring as set forth in API Tentative Standard RP-520.



This disc-type valve is energized by pressure in the vessel being protected and by product vapor pressure being applied to the upper portion of the disc through appropriate piping. The valve may be instrumented in any



HERE'S WHY THE BORDEN LABEL MEANS BETTER FLOOR GRATING . . .

BORDEN—First in Floor Gratings—is proud of its particular adaption and specialization in gratings for the refinery industry. **Borden's** well-known attention to detail and great familiarity with this special field guarantees complete satisfaction.*

Trouble-free installation is assured by **Borden's** Free Planning and Checking Service: All details and dimensions are carefully checked with the customer before fabrication; the component parts are individually marked for economical, accurate and speedy erection in the field.

*This applies to grating (usually stainless steel) for vessel and tower internals —such as grid trays etc.—as well as for strictly structural applications.

Write today for FREE
16-page catalog showing all basic types of grating; more than 30 dimensional drawings of subtypes; eight safe load tables for steel and aluminum grating.

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823 GREEN LANE ELIZABETH 2-6410 ELIZABETH, N. J.

Plants at: Union, N. J. — Leeds, Ala. — Conroe, Texas — Beeton, Ontario

BORDEN METAL PRODUCTS CO.

Gentlemen:

Please send me new 1961 BORDEN Catalog

NAME .....

TITLE .....

COMPANY NAME .....

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CITY AND STATE .....

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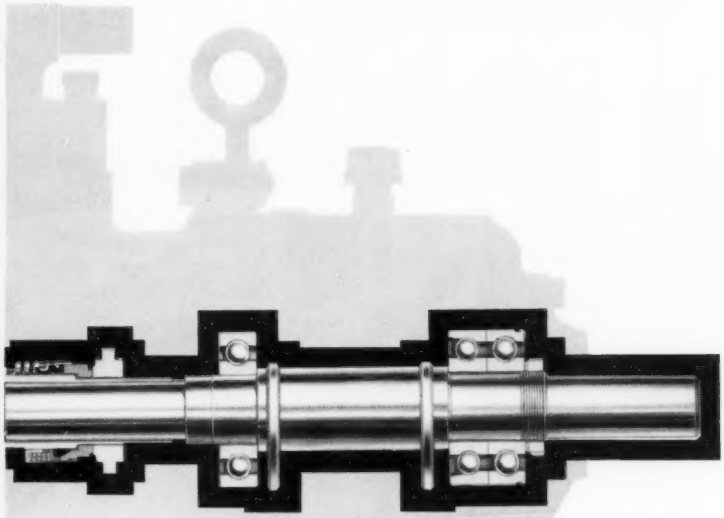
WHEN IT'S 750° HERE



...IT'S ONLY 250° HERE

intermediate-range pump HANDLES BIG, HOT JOBS

Now you can pump liquids *as hot as 750°F*—and handle pressures to 600 psi—with a pump that costs little more than a light-duty unit.

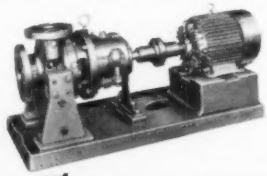
Goulds Model 3775 petroleum process pump can save you buying much heavier, costlier pumps for these jobs. It pumps 1200 gpm. And it is the only pump designed around a mechanical seal that gives you *both* high-temperature operation and easy upkeep of back pull-out.

Hot pumpage flowing through this pump never touches the mechanical seal—because the seal is isolated in its chamber and surrounded by cool, dead-ended liquid. Coolant circulates through jacket to hold seal face to 250°, even with pumpage at 750°. External flush or heat exchanger cooling is possible, too.

The seal is the *heart* of the pump, not an accessory. Because the pump is designed around the seal, it makes full use of seal advantages. Model 3775 has the lowest overhang ratio of any pump operating above 300°F. Its short shaft helps insure a true-running, long-lived seal.

Mechanically rugged, it is built to API 610 specs; centerline mounted with a vertically split casing. Typical of its quality is the dowel-pin fit alignment of bearing housing and casing cover, which assures perfect alignment and part replaceability.

To see where this cost-cutting pump can fit into your operations, send for our Bulletin 724-1. It gives specifications, construction details, pressure-temperature chart, and other helpful information.



Goulds Pumps Inc., Dept. PR-11, Seneca Falls, N. Y.

GOULDS PUMPS

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manner selected for remote opening and closing. Opening will always occur when pressure above the disc is vented by fusible plugs, control instruments or manual control. Valve can be reclosed.

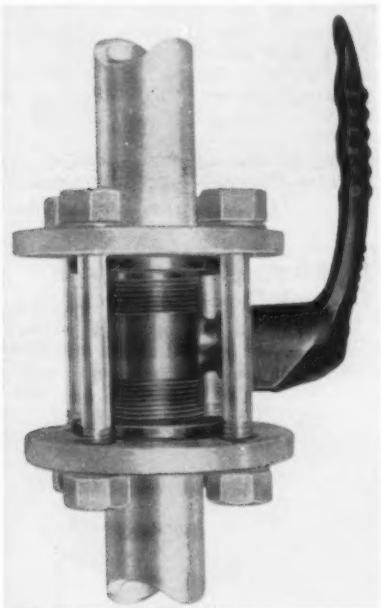
Model 4280 is designed to handle vapor over a wide range of pressures and temperatures. The basically simple valve design makes it economically adaptable to highly corrosive environments, through use of carbon or alloy steel. Shand and Jurs Co.

Circle E3 green card, last page

Ball Valves Eliminate Flanges, Thus Cut Costs

A series of compression-mounted ball valves available in all sizes ½-inch-2 inches, are supplied with through bolts for mounting between existing flanges and can be rapidly disassembled or assembled. The unique design of this valve eliminates the flanges on a flanged valve, thereby saving the price of two flanges with each valve. These valves are rated at a 1,000 psi cold non-shock service and 300 psi at 400° F.

The spray guard handle protects the operator's hand and the full port open-



ing of the valve eliminates turbulence. The adjusting shims prolong the life of the extra broad Teflon seats. The positive rectangular-slotted key drive in the ball eliminates ball and stem wear, ball wobble and assures positive rotation.

Equal flow can be achieved in either direction and the extra deep adjustable stuffing box with Teflon "V" ring packing to stop leakage can be repacked under pressure. The extra heavy duty stems guarantee longer service life with less maintenance or "down time." Cooper Alloy Corp.

Circle E4 green card, last page

Nicholson Thermostatic Steam Traps

These traps are only a fraction of your steam equipment cost . . . yet they can do a whale of a job in helping you to get full efficiency from that equipment even with varying pressures. Here's how.

Operating on a true balanced vapor-pressure principle, they discharge air, condensates and other non-condensables promptly, fully and intermittently. What's more, the bellows is located where it belongs . . . at the trap top . . . so that when live steam enters it contacts the bellows the moment the discharging condensate falls below the top of the inlet pipe. Thus, there is a constant water seal to prevent loss of live steam. This, plus the fact that valves and seats are accurately lapped for sure, safe shut off assures you of full thermal efficiency from every pound of steam. Capacity? These traps have it . . . up to six times greater than ordinary traps. Also since there's only one moving part . . . no links, pin, levers . . . your maintenance cost is next to nothing.

Get maximum Thermal efficiency from your equipment. Specify Nicholson Thermostatic Steam Traps. Immediate delivery.

W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.
Offices in principal cities

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Please send a copy of Catalog #400
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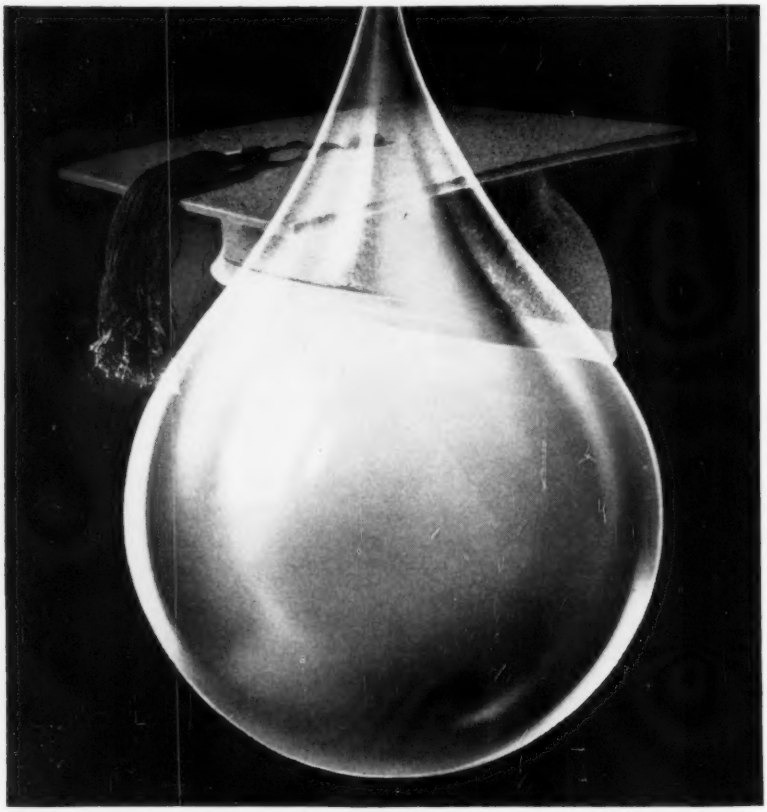
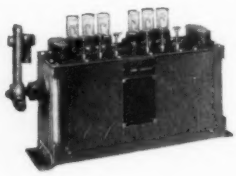
HOW TO educate



a drop of oil!

Just put it through a Manzel force-feed lubricator and any oil drop knows where it's going and how to get there fast. Manzel lubricators deliver just the right amount of oil to bearings, cylinders and packings. They start, stop, speed up and slow down in perfect synchronization with your machinery...unaffected by high steam, gas or air pressure. Whatever your field, there's a Manzel lubricator to meet your needs. For our catalog, write Manzel, 256 Babcock Street, Buffalo 10, New York. Whatever your lubricating problem, you get the right answer if you



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

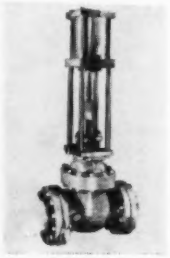
SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

New Equipment . . .

Cylinder Valve Operator Adaptable to Gate Valves

A universal type cylinder operator is adaptable to outside screw and yoke, iron body wedge or double disc gate valves. Factory-installed valves with cylinders are available, or the cylinders may be had in kit form for rapid in-the-field installation on iron body, hand-operated valves. Cylinder installation on valves already in service can be accomplished in 30 minutes or less.

The valves are actuated by a double-acting cylinder, using water, air or oil as the operating medium. The cylinders are controlled by operation of a four-way valve, which may be located in any convenient place within a reasonable distance from the main valve. Fixed orifices in the cylinder ports maintain an operating speed of one inch per second, minimizing slamming and sticking. No cushions or speed controls are necessary.

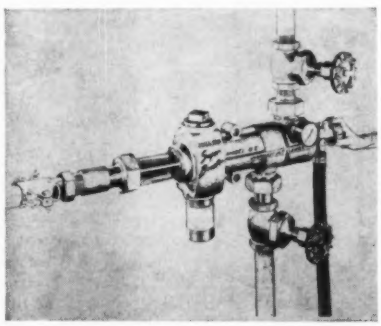


Seals are the "pressure sealing" type and meet Joint Industry Conference standards in every respect. The tube and seals are of Teflon. A piston rod stem coupling provides visual indication of the valve disc position, and can also be used for emergency manual opening or closing of the valve, eliminating any need for a tail rod. The Crane Co.

Circle E5 green card, last page

Jet Pump for Hot Liquids To Tank Cleaning Head

A high capacity hot liquid jet unit, for use where plant steam is available, can be used as a pressure pump feeding



the rotating heads of large capacity tank cleaning heads because of the high pressure and two-mile-a-minute jet stream velocity.

Using plant steam and water, the Model "BZ" produces a hot liquid jet with temperatures that can be manually controlled between 115° F and 210° F. Discharge hose pressures are more than

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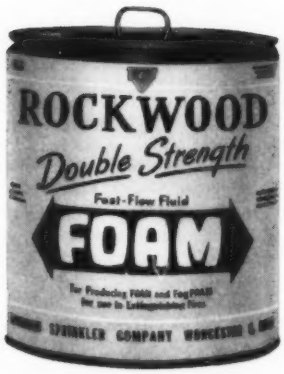
99.7%

of Rockwood FOAM protection is FREE!



ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company
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Engineers Water . . . to Cut Fire Losses

FOR FIRE FIGHTING purposes Rockwood Double Strength FOAM is inexpensive and completely effective. 3 parts *Rockwood Foam Liquid, plus 97 parts free water, plus 900 parts free air give you a fast low-cost fire extinguishing agent for only 1½ cents a gallon!*

Rockwood Double Strength FOAM puts out fires fast . . . reduces your storage costs . . . reduces shipping costs too! If you're using other types of special hazard fire extinguishing agents — you may not be using the most economical or most effective agent! We'll show you how to save on training cost and on fire fighting costs — and to fight fires better! Send in the coupon below. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal cities.

BLISS ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Department
507 Harlow Street, Worcester 5, Massachusetts

Please send me complete information on Rockwood fire-fighting products.

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Title.....
Company.....
Street.....
City.....*Zone*....*State*.....

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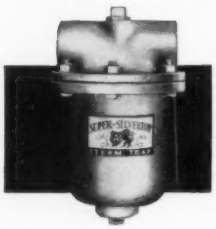
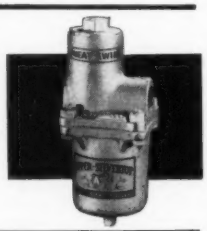
FOR STEAM PROCESS EFFICIENCY
WE RECOMMEND



Super-Silvertop
INVERTED BUCKET TRAPS for:

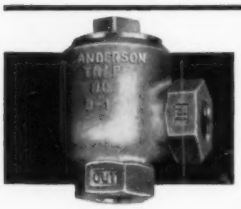
Autoclaves
Bare Pipe
Calenders
Coffee Urns
Convectors
Corrugated Paper Making Machines
Drain Pans
Dress Forms
Drips
Dry Cans
Dryers
Fan Systems
Flat Work Ironers
Header Drips
Hot Water Heaters
Kettles
Pipe Coils
Presses
Sock Forms
Steam Engines
Steam Mains
Steam Tables
Steam Purifiers
Sterilizers
Submerged Surfaces
Tumblers
Unit Heaters
Vacuum Canners
Warmers

Heat-Kwik
COMBINATION TRAPS for:



Autoclaves
Cooking Kettles
Dryers
Expellers
Kettles
Rendering Cookers
Retorts
Slashers
Submerged Surfaces
Tempering Apparatus
Unit Heaters
Water Heaters

or wherever fast heating up is desired

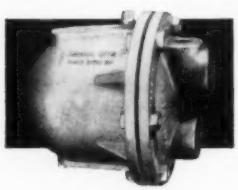


Quik-Flex
THERMOSTATIC STEAM TRAPS for:

Autoclaves
Cooking Kettles
Dryers
Expellers
Kettles
Retorts
Slashers
Sterilizers

or wherever fast heating up, or outside freeze-proof installations are required.

Anderson
FLOAT TRAPS for:



Air Purifiers
Gas Purifiers
Condensate Flow Meters
False Water Line Sewers
Master Trapping Separators
Air Separators
Gas Separators
Air Receivers
Gas Receivers
Gas Scrubbers

or wherever continuous discharge is necessary

Anderson has no "axe" to grind. With a complete line of traps we provide an honest recommendation for all your trap problems. Write for your free book "How to Select Steam Traps" . . . written to give you an unbiased opinion in answer to all your steam trap difficulties.

SUPER SILVERTOPS STEAM TRAPS
BY THE MANUFACTURERS OF Hi-eF PURIFIERS

THE V. D. ANDERSON COMPANY
Division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio

New Equipment . . .

double inlet steam pressures. Capacity ranges from 2,000 to 10,000 gph.

Initial cost of the unit is said to be considerably lower than that of comparable capacity high-pressure pumps used for handling hot or corrosive liquids.

Made of Naval M bronze and stainless steel, the unit contains no moving parts. Since no lubrication is required, maintenance costs are virtually eliminated.

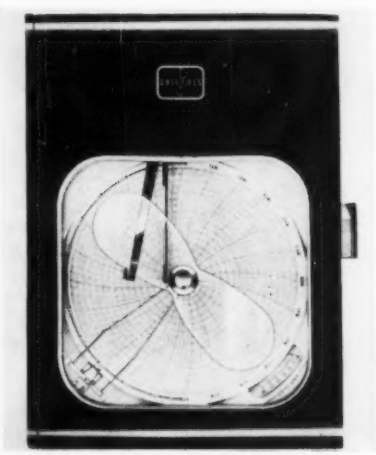
Means are available for introducing chemicals or detergents into the jet stream by merely hand turning a control valve. Detergents can be used up to 10 percent by volume of the jet stream. Sellers Injector Corp.

Circle E6 green card, last page

Recorder-Controller Cuts Panel Space in One Case

A single-case, time-program recorder-controller incorporates the recorder and controller into a single unit which affords a 50 percent reduction in panel-space requirements.

The recorder chart and the program cam are independently driven. This



makes it possible to record repetitions of the program on a single chart. The program time may be from 30 minutes to 30 days.

Various models of the instrument measure and control temperature, pressure (including absolute pressure), flow (mercury manometer or bellows-differential meter), liquid level, and humidity.

Either pneumatic control or electronic control is offered. Pneumatic control can be "on-off," or proportional or reset control. The Bristol Co.

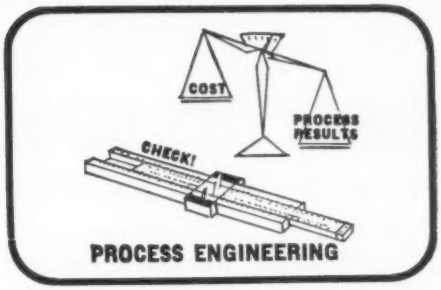
Circle E7 green card, last page

Ready-Mixed Epoxy Enamel Eliminates Field Mixing

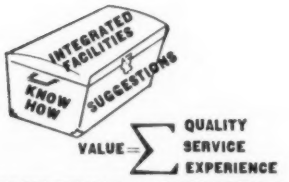
Ready-mixed epoxy enamel for maintenance coating on surfaces and equipment exposed to alkali and acid fumes

When evaluating a product—

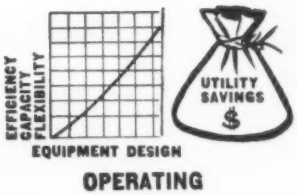
Your Process Engineers Make Decisions That Are Very Important to the Quality and Quantity of Your End-Products...

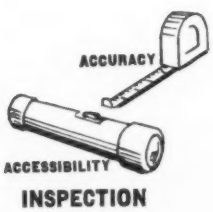


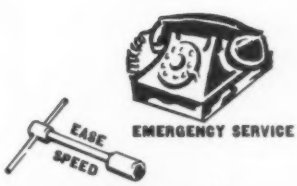
Process Results of Glitsch Equipment Far Outweigh Their Cost—

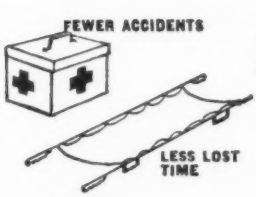


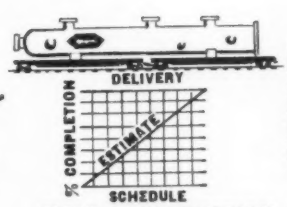
Glitsch Ballast Trays and other fractionating equipment, including the Glitsch-Grid, offer additional process results that are valuable to your process engineering design requirements. The cost/value ratio justifies the use of Glitsch equipment because *if you need Glitsch "plus-quality" and do not buy it, you pay for it without getting it.*

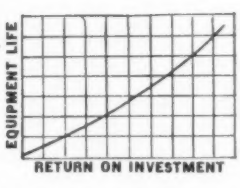












PRODUCTS — Glitsch Lightweight "Truss-Type" Ballast Trays, Sieve, Bubble Cap, Dualflow, Disc, Donut, Accumulator, and Mist Eliminator Trays ... Pressure Vessels, Contactors, Reactors, Filters, Heat Exchangers, and Other Specialty Products ... Bubble Cap and Riser Assemblies, Flanged and Dished Heads, Machine Time, Stampings, Knitted Wire and Woven Wire Screen.

TECHNICAL — Fractionating Tray Engineering: Process, Mechanical, Structural, and Metallurgical Designing. **Pressure Vessel Engineering:** Pressure, Temperature, Wind, Earthquake, and Dynamic Designing. **Special Product Engineering:** Research and Development and Model Mock-Up. **Special Tooling and Machine Design** for Specific Purposes and Problems.

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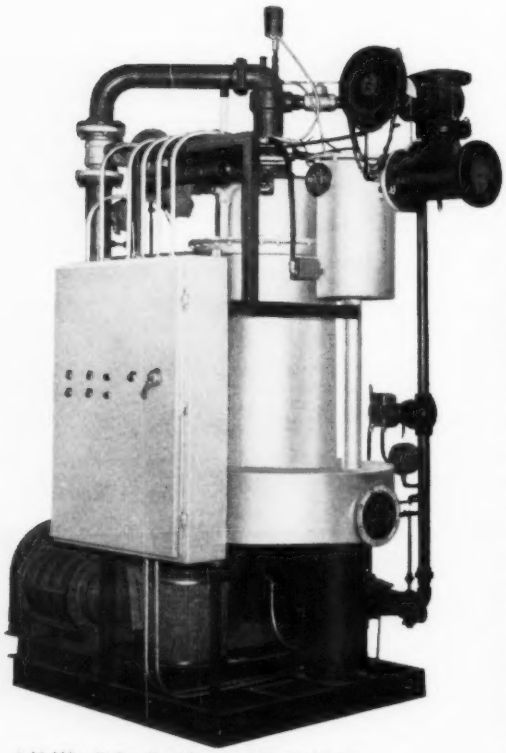
For more data on advertised products, use Readers' Service Cards, last page.

THERMAL
INERT GAS GENERATORS

Using the Thermal Sub-X Process

THERMAL utilizes unique principles of design to provide refineries, chemical processors, metallurgical plants, and other industrial users with a source of inert or purge gases that is compact in size and provides high outputs for low initial cost. Standard outputs range from 2,000 scfh to 60,000 scfh.



A 30,000 scfh Gas Fired Generator Ready for Use

SUBMERGED EXHAUST OF COMBUSTION PRODUCTS makes feasible the use of low-cost or contaminated water as coolant without concern over fouling of surfaces. The tank of water through which the gases pass provides an unusual degree of safety. Heat transfer efficiency is extremely high.

REFRACTORY IS ELIMINATED and maintenance costs reduced through the use of the high heat release THERMAL burner which can be fired with gas, distillate oil, or dual fuel. Units are supplied as a complete package and include all control and safety equipment.

For detailed information write for Bulletin #114-B

THERMAL

Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

Other Thermal Products & Services:

Gas, Oil & Combination Burners
Heat Exchangers
Air Heaters
Submerged Combustion
Combustion & Heat Transfer Equipment

New Equipment . . .

is being introduced under the trademark of "Corlar."

Epoxy ester paints have been growing in popularity, competing with air-dry phenolic and chlorinated rubber compositions. They offer an order of chemical resistance between the catalyzed epoxies and alkyds.

A single-package material, "Corlar" ready-mixed epoxy enamel eliminates mixing in the field as well as the problem of the limited pot life of catalyzed epoxy formulations.

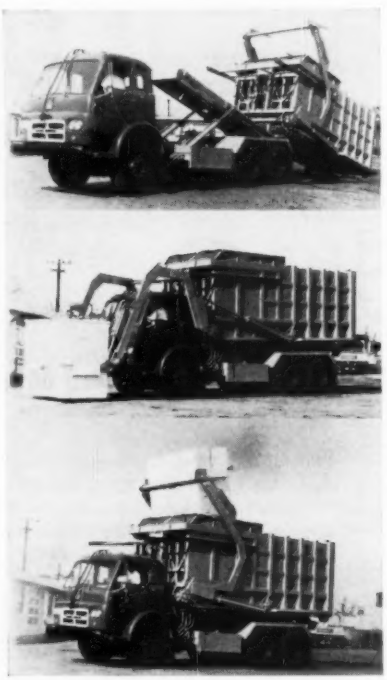
In addition to a high level of chemical resistance, it has good durability in salt air exposure, persistent condensate, and moisture. It stands up well under the destructive action of alkaline machine tool cutting oils.

It is now available in white and nine colors, and is easy to apply by brush, roller, or spray. It dries tack-free in six hours and is recommended for wood, masonry, and metal. E. I. duPont de Nemours & Co., Inc.

Circle E8 green card, last page

Refuse Handling Unit Latest in Versatility

A new refuse container handling unit, the "Dinomaster," gives the company's Dinosaur a new versatility to such a degree that it can now serve as a complete system for both heavy materials handling and general refuse collection and disposal for most plants.



The Dinosaur, which has previously been used in petroleum plants for containerized cargo, chemicals, raw materials and waste products, now becomes a

Which valve alloy for your next job?

When you next have a requirement for high alloy valves, especially for corrosion service, why not come to the company with the most experience in this field.

Aloyco has specialized in the manufacture of stainless steel valves, exclusively, for over 30 years.

We have accumulated a wealth of know-how, not only on how to engineer valves for hard-to-handle corrosives, but also on what alloys are the most efficient and will give the longest life.

Aloyco's field consulting service is yours for the asking. Why not write or call our nearest sales office for help on your next alloy valve job. Alloy Steel Products Company, 1303 West Elizabeth Avenue, Linden, New Jersey. 9.10

Offices in: Boston • New York • Wilmington Atlanta • Buffalo • Pittsburgh • Chicago St. Louis • San Francisco • Los Angeles

***These seven corrosion test specimens** are just a few from hundreds of tests conducted by Aloyco to insure our valve customers of the right alloy for their particular job. Aloyco valves are supplied in such metals as 304 and 316 stainless steel, Aloyco 20, Nickel, Monel and Hastelloy B, C and D.*

ALLOY STEEL PRODUCTS COMPANY

LINDEN, N. J.

IN WOVEN WIRE SCREEN AND WIRE CLOTH PRODUCTS

Whether you are grinding, sizing, scalping, dewatering or filtering it's the accuracy of the "working opening" that makes the difference in woven wire screen and wire cloth products. We pride ourselves in weaving accurate "working openings", an engineered screening surface to meet your specification.

First, the best metal or alloy is selected—hard enough to withstand the abrasive action—ductile enough not to break under stress. Next, the best wire diameter and crimp are determined. Then we weave wire screen or wire cloth around accurate "working openings" best suited for your screening application.

FREE! Write for bulletin 160 giving complete details and facilities.

THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET • CLEVELAND 5, OHIO

FLANGE + SEAMLESS BODY = GREATER ECONOMY

Lenape Type D External Reinforcing Nozzle with ASA Bolt Flange

By combining a Lenape ASA bolt flange with your choice of 3 seamless bodies, you achieve optimum reinforcement and design flexibility with unmatched economy. Hard to believe? Contact your Lenape representative for details, or write for a copy of the Lenape General Catalog.

LENAPE

Red Man Products

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PENNSYLVANIA

New Equipment . . .

complete materials handling tool for large and small plants alike by the addition of the new unit.

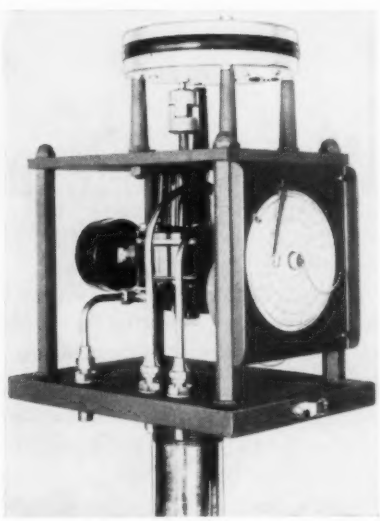
The new development, which consists of a compaction body and two cab-clearance lifting arms mounted on a standard Dinosaur frame, can be operated as a self-loading packer when automatically pulled up on the skid frame and locked in place.

In operation, it is very similar to the company's Dumpmaster, now in service in many petroleum plants, in that it approaches a refuse storage container, engages the side channels, lifts it over the cab and empties the contents into its compaction body, where the material is squeezed to a fraction of its former volume by action of the 60,000-pound thrust of the packer plate. Dempster Bros.

Circle E9 green card, last page

Gas Sampler Gets 7-Day Sample at Constant Rate

A new continuous gas sampler for the accurate determination of chemical and physical properties of gas will, over a period of seven days, accumulate at a



constant rate a sample of gas to a final pressure at or near 140 psig from the sample source—the minimum pressure of which is not less than 160 psig.

An important feature of the Model M-R is that it is supplied with a mechanical drive and includes a pressure recorder in a single case and is available for sample ranges up to 150 psig when required. However, the instrument can be furnished for lower pressure samples.

The design is based on the principle that the maintenance of a constant rate of increase in gas pressure within a closed container will result in a constant rate of flow of gas into the closed container. This constant rate of increase is accomplished by means of a regulation

For more data on advertised products, use Readers' Service Cards, last page.

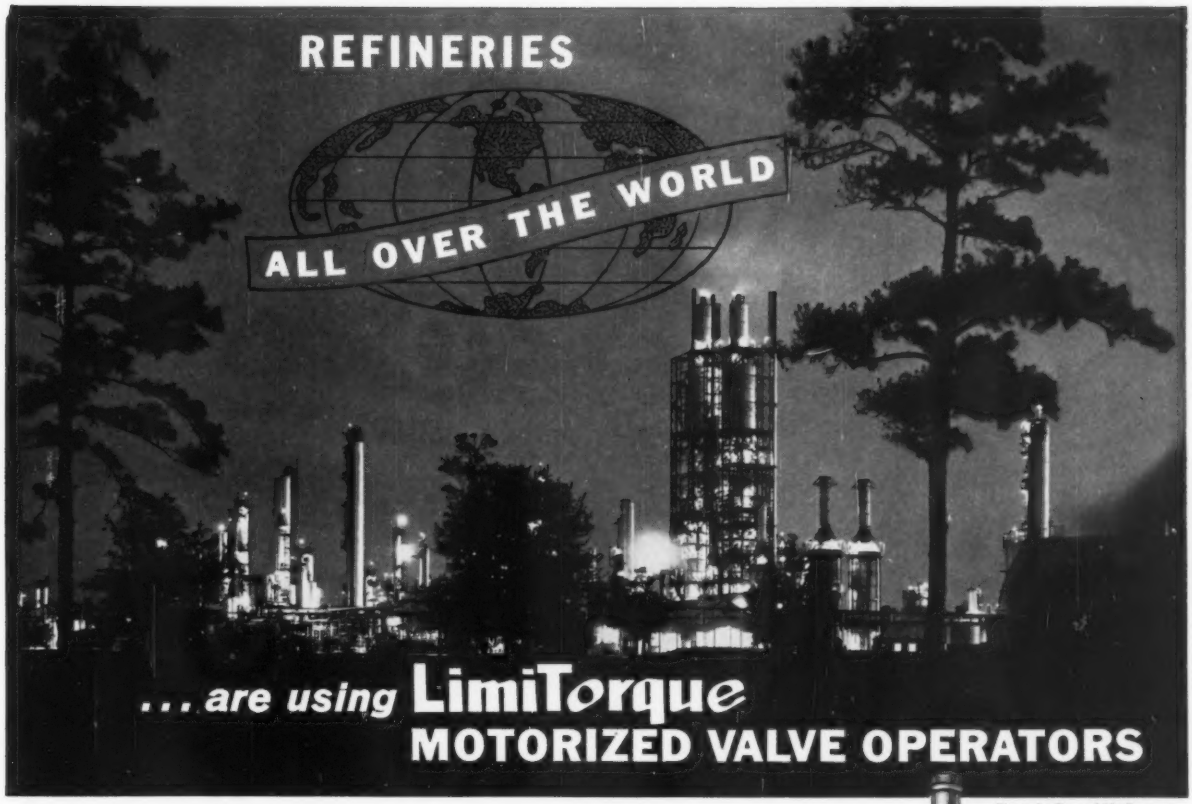
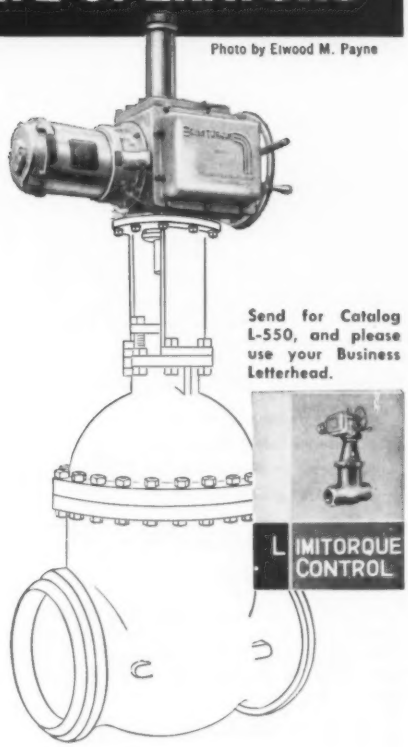


Photo by Elwood M. Payne

It is highly significant, that wherever there is a Modern Refinery, you will find vital valves operated day and night by LimiTorque Push-Button Motorized Controls . . . The reasons for such wide-spread use are many; first of course is their ABSOLUTE DEPENDABILITY under all pressure, temperature, and service conditions . . . Second, LimiTorque operators are ruggedly built, yet as accurate as a fine watch . . . And, because of a specially designed Torque Limiting Mechanism, they ELIMINATE ANY POSSIBILITY OF DAMAGE TO VALVE PARTS during the cycle of operation . . . also vitally important is the fact that they save TIME, LABOR AND MONEY . . . and, it should be kept in mind that LimiTorque is manufactured by one of the largest gear and geared products manufacturers in the World . . . it is the result of 28 years of experience.

For further information consult your valve manufacturer, or your nearest LimiTorque Sales-Engineering Office.



Send for Catalog L-550, and please use your Business Letterhead.

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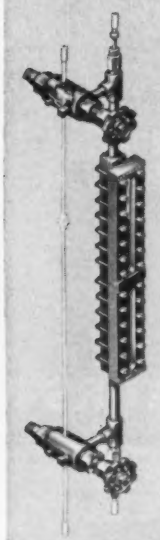
KING OF PRUSSIA (SUBURBAN PHILADELPHIA), PA.

Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • King of Prussia, Penna.

When you need
HEATED GAGES
and
VALVES



select from a complete line . . . Jerguson offers you a model for every need

Jerguson Heated Gages and Valves are built to meet the special conditions present when working with liquids which must be kept at higher than ambient temperatures . . . for process reasons or to hasten the speed of response to level changes. They also have wide application to prevent breakage through freezing.

Select from a complete line

- Reflex or transparent gages
- Union or non-union valves
- External or internal heating
- Steam or electric heating
- Materials meet or exceed AISI, ASTM and/or API-ASME requirements

New Electric Heating

Electrically heated gages have a completely new heating system with greatly improved efficiency. For use where steam is not available. Offered in External Tube Models only.

Write for Heated Gage Catalog.

JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities

New Equipment . . .

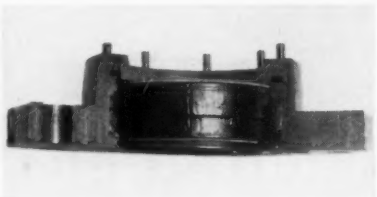
system equipped with a precision driving mechanism.

The gas sample is gathered in a portable container for easy access to the laboratory. The instrument can be employed in any hazardous area where vapor proof equipment is required because it needs no external source of power. Arcco Instrument Co., Inc.

Circle E10 green card, last page

Revolutionary Sight-Glass Stops Blow-Out Failures

After several years of research, a revolutionary new sight-glass has been developed which is infinitely safer and more reliable than previous models. Safety



range of the new unit is maximum from ultra-high vacuum to 30,000 pounds pressure per square inch.

Rupture or other unpredictable failure of the sight-glass makes a conventional lens a veritable projectile in blow-out. Stresses on the glass lenses, as well as metal mounting of conventional sight-glasses, often contribute to their failure. The new control protects against this hazard. Through its unique mounting design, the unit inherits the strength of the material to which it is attached and eliminates uneven stress.

A cut-away view shows the packing and assembly of the new safety sight-glass (see photo). Unique mounting accommodates the pressures and temperatures sight-glasses must contain. Compressing the circumference of the lens assembly, it eliminates the possibility of rupture or blow-out destruction of the control by directing equal distribution of all stresses against the glass.

Design and manufacture of the unit makes it virtually impossible to fail through blow-out or rupture so common in conventional models. Pressure Products Co.

Circle E11 green card, last page

Pump Uses Both Vane, Centrifugal Principles

A new booklet describes a unique motorpump that combines a vane-type priming pump with a conventional high-efficiency centrifugal pump to get the advantages of both.

Used to handle a variety of liquids, the "centri-prime" pump is specifically designed for work involving suction lifts or vapor handling problems. It is par-

NOW
competitively priced!
NEW
Aeromaster
INDUSTRIAL COOLING
FAN
featuring
"QUICK-SWITCH"
BLADES

Blades can be installed after hub is mounted on drive shaft

Performance, construction, and price make this the "best buy" in industrial fans! Delivers more CFM with *less* H.P. Features a ductile iron hub, removable blade retention caps, heat treated aluminum alloy blades with constant chord width and flanged ends. 4, 6 and 8 bladed fans available in 54″ to 120″ diameters. Maximum tip speed is 15,000 ft./min. Easy to install . . . easy to maintain. For complete details, write: KOPPERS COMPANY, INC., 5101 Scott Street, Baltimore 3, Md.

KOPPERS Aeromaster Fans
Engineered Products Sold with *Service*

Solar gas turbine stimulates production of oil and gas wells

OIL FRACTURING OPERATIONS — used to stimulate production of oil and gas wells — must take place at the well site. This means that fracturing and acidizing pumping units must be lightweight and mobile — yet provide in excess of 1000 hydraulic horsepower for most operations.

The Western Company's new 1000 hydraulic horsepower fracturing pump is powered by Solar's *Saturn* T-1000 gas turbine engine. Up to 1250 hp is required to drive the pump in this application. Weight of the truck and turbine-driven fracturing unit is significantly less than 500 hp diesel units currently used by Western. The *Saturn* T-1000 turbine-powered pump delivers twice the hydraulic hp of the diesel units — reducing by 50% the number of units needed per operation.

The *Saturn* T-1000 engine weighs only 1200 lbs and occupies less than 51 cubic feet. It is simple in design, starts instantly from −65 degrees F to 130 degrees F, and takes full load in seconds without warmup. It has been engineered for simplicity of operation and long life under industrial conditions. As a compact and reliable power source for generators, compressors, pumps, and other oilfield equipment... investigate the *Saturn* T-1000 gas turbine. There's a Solar gas turbine for almost every application in the 50 to 1250 hp field. Write for particulars to Dept. H-194, Solar Aircraft Company, San Diego, California.

SOLAR
AIRCRAFT COMPANY
A subsidiary of International Harvester Company

For more data on advertised products, use Readers' Service Cards, last page.

You don't have to be a Monkey—

. . . to loosen frozen bolts on utility poles. The new Aerosol Kroil, which can be squirted with one finger, loosens the most stubborn frozen metal parts . . . FAST. More than 18,000 shops depend on Kroil whenever frozen metal parts threaten to tie up production or waste manhours. In this new package it is the finest rust-busting tool ever . . . shoots a stream 3 ft. yet won't leak. One customer said, "before trying Kroil we broke off every nut (on our heat treat trolleys), since then we have not lost one and have decreased the repairing time from 30 minutes to about 6 minutes per trolley."

KANO KROIL LOOSENS FROZEN METAL PARTS

Use Kroil on all dismantling jobs; for filing, sawing, honing; . . . also keeps air driven tools running freely.

Just try Kroil on a make good basis. Case of 12 Aerosol Kroil 12 ounce cans $18.75 f.o.b. factory or send $2.00 for one can postpaid. If it doesn't perform to suit you, return the empty can for refund.

KANO LABORATORIES 1094 THOMPSON LANE NASHVILLE 11, TENN.

SPRAY NOZZLES

greater choice of patterns

Full Cone
Hollow Cone
Square Spray
Flat Spray

greater choice of capacities

greater choice of materials and spray nozzle types

Over 12,000 Standard Spray Nozzles for more exact performance to fit your needs

For complete information write for Catalog No. 24

SPRAYING SYSTEMS CO.
3283 Randolph Street • Bellwood, Illinois

Babbitt *Adjustable* SPROCKET RIM *with Chain Guide*

CHANGES THAT DANGER ZONE TO A SAFETY ZONE

. . . saves you money ON EVERY VALVE

Every minute saved is money in your pocket. Cut out the waste of time, labor, floor space due to hard-to-reach valves. At the same time convert Danger Zones to Safety Zones. Equip every overhead valve in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides for day to day economy.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us direct.

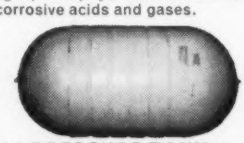
Babbitt STEAM SPECIALTY CO.
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

FLUID & GAS PRESSURE TANKS

STAINLESS & CARBON STEEL TANKS

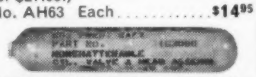
(GOVERNMENT SURPLUS BARGAINS)

Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.



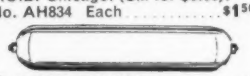
J-1 PRESSURE TANK Stainless steel, surplus aircraft oxygen tank. 48" long, 24" dia. Rated for 400 P.S.I. working pressure, 18,000 cu. in. vol., 77.9 gal. capacity. ¼" pipe thread fitting at each end. New condition. Shipping weight 247 lbs. F.O.B. Chicago.
No. AH832 ..... $99.50

G-1 TANK Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AH63 Each $14.95



NON-SHATTERABLE CO_2 CYLINDER This type of pressure bottle was used by the Armed Forces for inflating life rafts. 18¼" long, 3¾" dia. Has ½" pipe thread opening at one end. Capacity 2.98 lbs. of CO_2—at 1800 P.S.I. Shipping weight 10 lbs. F.O.B. Chicago.
No. AH303 ..... $2.50

FREON TANK Capacity 22 oz. of Freon F22, 6 cc Methyl Alcohol. 18¼" long, 2" dia. ⅜" pipe thread opening at one end. Equipped with brass valve. Shipping weight 3 lbs. F.O.B. Chicago. (Six for $8.00).
No. AH834 Each $1.50



D-2 AIR TANK Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ½" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
No. AH391 Each $4.95

CORNELIUS HIGH PRESSURE (1500-2000 P.S.I.) AIR COMPRESSOR Three cylinder, 3-stage compressor, complete with 27 volt, D.C. 20 amp. motor, with fan. Rated 1500 P.S.I. continuous duty, 2000 P.S.I. intermittent. Pressure switch in base. As released by Air Force, in used, serviceable condition. Covered by our 30 day GUARANTEE. 11½" long, 7" high, 9" wide. Shipping weight 12 lbs. F.O.B. Chicago. Limited quantity.
No. AH549 ..... $35.00

Write today for FREE CATALOG of other EQUIPMENT BARGAINS!

GROBAN SUPPLY COMPANY
1139 SOUTH WABASH AVE., DEPT. AH-1, CHICAGO 5, ILL., WEbster 9-3793

ticularly useful for handling petroleum products. The booklet presents sketches of pipe-pump-tank layouts showing top unloading of a tank car; top unloading a transport; pumping from underground storage, and combination loading, unloading, and transfer.

Text and drawings in the booklet show how the priming pump unit evacuates air and/or vapor from casing and pipe, creating a partial vacuum and a flow of liquid which floods the casing, after which the conventional centrifugal pump takes over.

Performance curves, reproduced in the booklet, show gallons per minute and total head in feet for the four models of the new pump. The pumps deliver up to 600 gallons per minute, with heads up to 120 feet and lifting or suction heads up to 19 feet.

A priming time graph presents data on the rated priming time of pumps employed with pipes of various dimensions and various lifting heads. Depending on pipe diameter and head, priming time ranges from one to five seconds per foot of pipe. Ingersoll-Rand Co.

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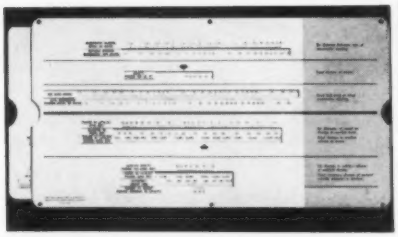
Fluid Cracking Problems Solved with Slide Chart

A new technical aid for engineers concerned with fluid catalytic cracking called the "Davison Catulator" is a



6½ x 12-inch plastic-coated slide chart. In brief, it can be used to calculate:

- Catalyst carbon burning rate and hydrogen on coke directly from a flue gas Orsat analysis.
- Catalyst bed densities and levels directly from manometer readings.
- Catalyst vessel inventories and addition rates directly from level changes.

A product service bulletin sent with the slide chart gives the uses of the device in detail. Davison Chemical Div., W. R. Grace & Co.

Circle E13 green card, last page

Flame-Cutter Reproduces Metal Parts from Drawing

A complete line of Oxweld flame-cutting machines is described in a 28-page catalog. Machines described range in size from small, handy, portable machines that can be carried around a shop by one man to huge-multi-torch, shape-

GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAYLOC SALES DIVISION

GRAY Tool Company

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05

For more data on advertised products, use Readers' Service Cards, last page.

cutting machines capable of reproducing tens or thousands of the most intricate shapes and patterns in steel.

The unique new photocell tracer is also described. This new unit makes it possible to reproduce complicated metal parts from exact size pencil or ink drawings. The new tracer which can be used with stationary machines described in this catalog eliminates the need for expensive metal, wood or plastic templates, or complicated silhouettes.

Also included are complete specifications for each machine, illustrations of typical installations, and a description of a wide variety of machine accessories. Linde Co. Div., Union Carbide Corp.

Circle E14 green card, last page

New High-Strength Steel Offered at Reduced Cost

Significant savings in the fabrication of stronger, lighter steel structures and equipment are promised by a new, low-cost constructional alloy steel designated as "T-1" type A steel. The new alloy is available in quenched and tempered plates and bars ranging from 3/16 to 1 inch thick inclusive.

In this thickness range, "T-1" Type A steel has the same 100,000 psi minimum yield strength as "T-1" steel, which was introduced in 1953. Also, in thicknesses up to 1 inch inclusive the new material and the original "T-1" steel exhibit the same degree of toughness, weldability and resistance to impact abrasion. However, "T-1" type A steel costs significantly less because of difference in chemical composition.

If extra hardness is needed, "T-1" type A can be furnished to a minimum Brinell hardness of 321. United States Steel Corp.

Circle E15 green card, last page

Hydraulic Valve Actuator Eliminates External Valves

A hydraulic valve actuator has been developed on which motor and pump run only for the few seconds required to open or close the valve, and which provides an automatic locking feature that holds gate or plug in any desired

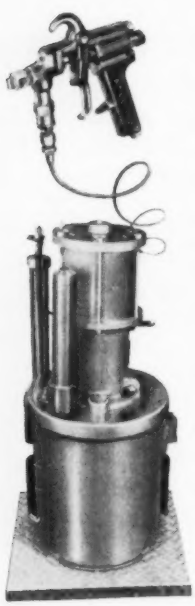
position almost indefinitely.

Suitable for use on virtually any type or size of valve, the complete unit, including motor, pump and coupling, integral reservoir, pressure switch, hand pump, gages and any required safety devices, fits well within over-all valve

PAINTING CONTRACTOR REPORTS IMPROVED EFFICIENCY WITH SPEE-FLO HYDRAAIRLESS 30 AND H-GUN

The W. D. Gunnels Company, operating nationwide, employs over 250 people in industrial and commercial work.

Mr. Wm. H. Stemler, Vice President
W. D. Gunnels Company
Freeport and Houston, Texas



"We perform maintenance in many plants where corrosion is a big problem," says Mr. Stemler. "It is extremely important that we work fast and get full coverage in high-corrosion areas. The atomization efficiency of the HydraAirless 30 allows us to spray epoxies, vinyls and other high-viscosity, protective materials, easily. As a result, we get the desired mil thickness with fewer coats than we had to apply previously. This not only saves a lot of time, it reduces the possibility of contamination between coats; thus providing a better job for the customer. With the HydraAirless 30, we cover a lot of area fast since we are operating three guns on 100-foot hose lengths from one unit.

"At present, we have four Spee-Flo HydraAirless 30 units. We're extremely pleased with the performance and trouble-free operation!"

If you'd like to use airless, but have tried it without getting the desired results, we urge you to see a demonstration of the H-GUN and HydraAirless. For heavy-duty maintenance or highest-quality, fine finishing, you'll find there is none better.

Contact your nearest distributor or write to Spee-Flo.

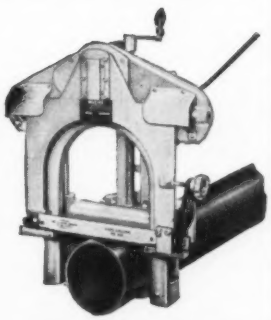
6614 Harrisburg Blvd. • Houston 11, Texas

The Spee-Flo Company

Here are tools you need for

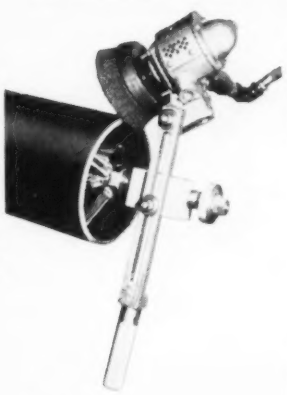
MAINTENANCE!

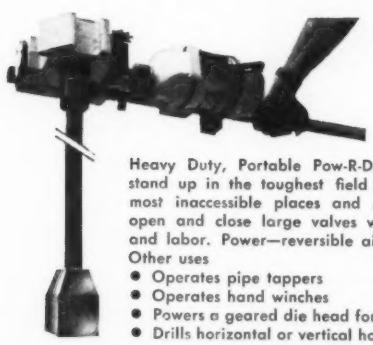
Wachs Guillotine® Saws cut steel, cast iron or stainless steel pipe as well as bar stock, structurals and rail. Fast, safe and accurate. V-Base assure square cut every time in any position and tight places.
Electric or air drive.
Model C—Capacity 2" thru 8"
Model D—Capacity 10" thru 18"



Wachs National Pipe Saw, "the Milling Machine on Wheels" travels around the pipe. Makes fast, accurate and safe cuts on steel, cast iron or cement-lined pipe. Cuts bevels for welding. Machine adjusts to all sizes from 10" to 72" diameter.

Easy, fast and accurate, the Wachs Bev-L-Grinder produces clean faced uniform weld bevel preparation without any change in physical properties of steel pipe.
Self-centering mandrel provides spindle to guide Bev-L-Grinder head assuring accurate weld preparation—grinder travels in true plane.
These factors make good line-up and fit easier in the field. This makes it possible for field crews to get highest quality welds.
Two Mandrels—
#E for pipe 3" thru 6"
#G for pipe 4" thru 18"



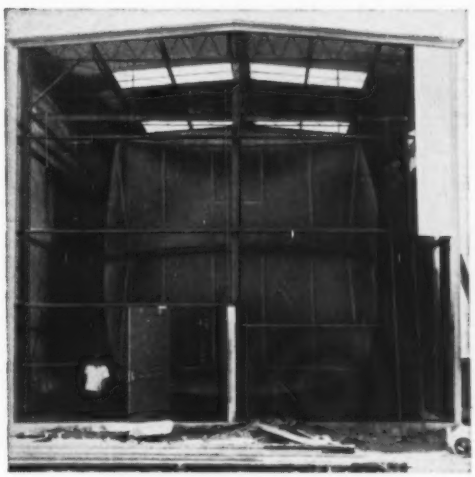


Heavy Duty, Portable Pow-R-Drive is ruggedly built to stand up in the toughest field jobs. Can be used in the most inaccessible places and delivers ample power to open and close large valves with great saving of time and labor. Power—reversible air or electric drive motors.
Other uses
- Operates pipe tappers
- Operates hand winches
- Powers a geared die head for threading or cutting
- Drills horizontal or vertical holes with an auger

Write for descriptive bulletins

THE E. H. WACHS COMPANY
Manufacturers of Engines, Valves and Machinery since 1883
1525 NORTH DAYTON STREET · CHICAGO 22, ILLINOIS

BIG SAVINGS WITH LOW-COST REEVES-VULCAN BREATHER BALLOONS



Stop vapor loss with this air-tight, self-contained, completely closed system.

Now—with a low-cost Breather Balloon installed in new or modified storage systems, you can capture the vapors that might otherwise be lost during the storage or transfer of volatile liquids. Reeves-Vulcan Breather Balloons require no skilled labor to install, no high priced housing . . . cost practically nothing to maintain.

Ultra-high strength neoprene-coated nylon gives these rugged balloons unusually long life. Every Breather Balloon installed is still in use, still returning profits. Make your storage tank a closed system . . . install Reeves-Vulcan Breather Balloons—the most efficient and most economical system of vapor conservation ever developed for low to medium storage volume.

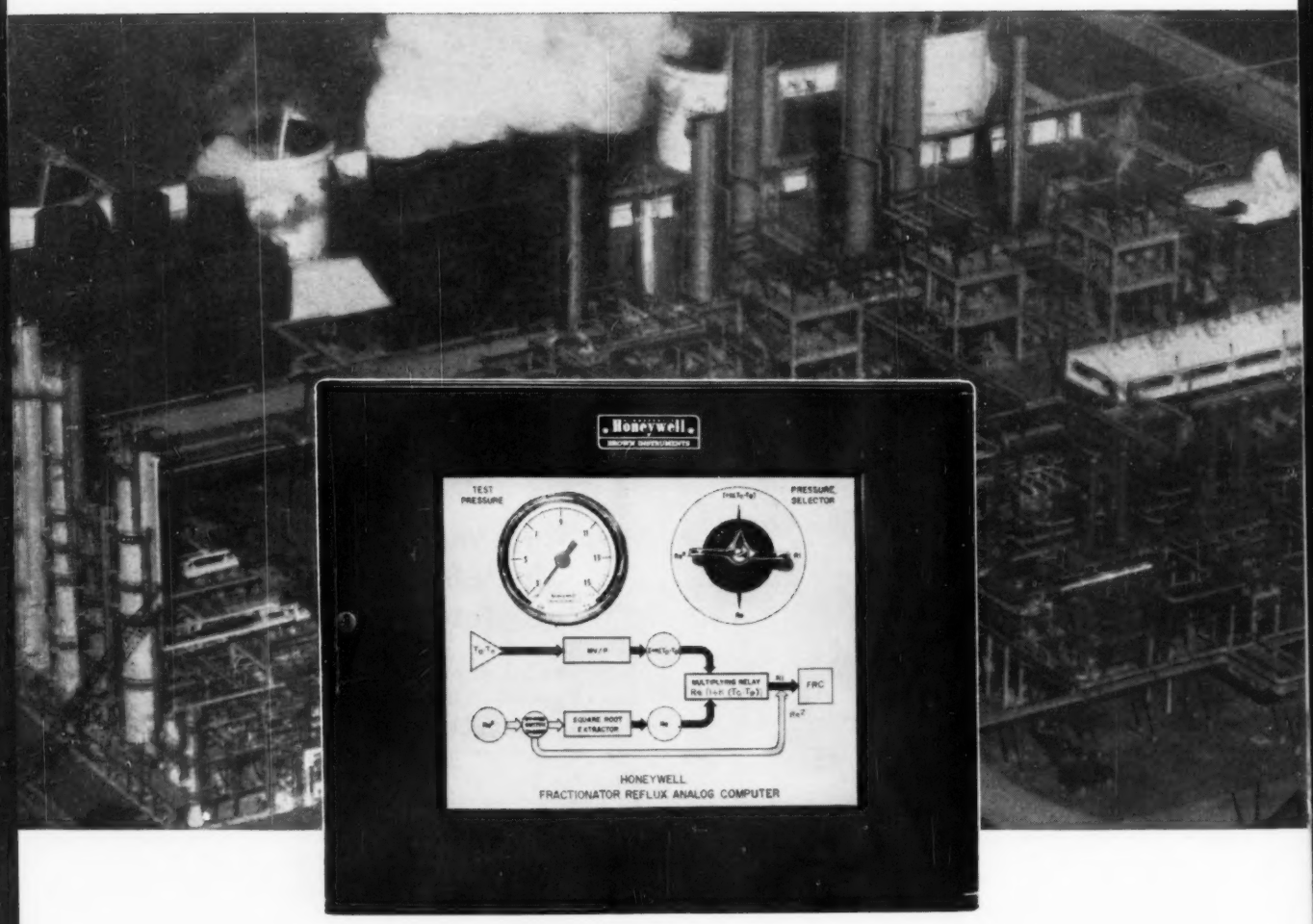
For free, informative brochure, write to: Reeves Brothers, Inc., Vulcan Rubber Products Division, 1071 Avenue of the Americas, New York 18, New York.

REEVES VULCAN
Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

For more data on advertised products, use Readers' Service Cards, last page.

Stabilize Fractionating

with new Honeywell



HONEYWELL *FRAC* CONTROLLER IS EASY TO USE AND MAINTAIN

- Standard Honeywell components, packaged in a standard Honeywell strip chart recorder case—completely wired and internally piped.
- Only four simple, easily accessible process connections required to put the unit in operation.
- Chassis pulls out for front-of-case servicing, simplifying adjustment and maintenance for your instrument technicians.

COMPONENTS

MV/P (millivolt-to-pressure) Transmitter

- Fully transistorized
- Continuously sensitive to temperature change
- Constant voltage supply
- Simple span and zero adjustments

Pressure selector and test pressure gage

- Provide check of all pneumatic pressures within the computer for simplified trouble shooting.

By-pass switch

- Permits switching from *FRAC* control to conventional external reflux flow control.

Column Operation

*FRAC** Controller

- **Easily installed and maintained by present instrument technicians**
- **Savings realized justify installation**
- **Tamper-proof design**

This new Honeywell control system immediately adjusts column operation to the effects of ambient temperature on overhead product condenser and external reflux. It continuously computes internal reflux flow, to maintain the most efficient, economical fractionating tower operation.

The new method, originally developed and licensed by Phillips Petroleum Company, utilizes a simple Honeywell analog computer employing standard Honeywell electric and pneumatic instrument components.

By correcting instantly for temperature deviation, the new control system offers the following economies.

- Less reboiler heat is required, because large surges of internal reflux that would lower temperature are eliminated.
- Reduction in off-specification product minimizes re-runs and the need for intermediate storage.
- Closer control permits fractionator to operate closer to the flooding point.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

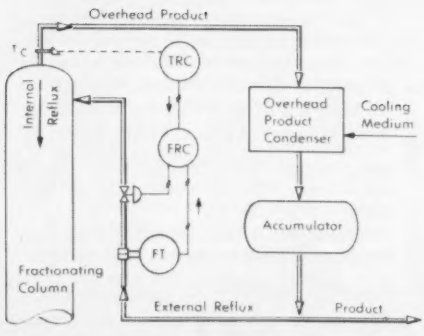
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

**Fractionator Reflux Analog Computer. Trademark, Minneapolis-Honeywell Reg. Co.*

Honeywell

H HONEYWELL *First in Control*

SINCE 1885



PROBLEM with existing fractionator control systems—Column is upset when temperature of external reflux is indirectly affected by changes in atmospheric conditions or in the temperature of the cooling medium to the condenser. Result: off-spec product, wasted reboiler heat, lower fractionator capacity.

$R_i = R_e[1 + K(T_o - T_e)]$

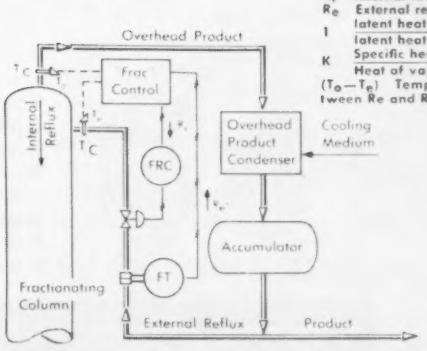
R_i Internal reflux

R_e External reflux

1 latent heat of vaporization of R_e / latent heat of vaporization of R_i

K Specific heat of R_e / Heat of vaporization of R_i

$(T_o - T_e)$ Temperature difference between R_e and R_i

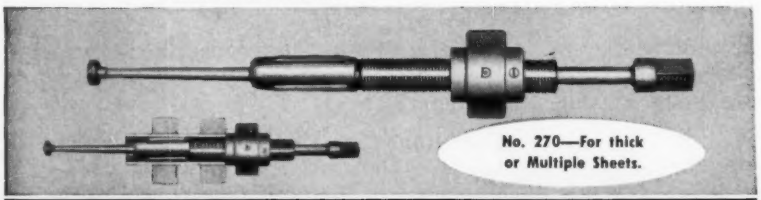


SOLUTION: FRAC Controller (1) measures external reflux flow rate (R_e) and the temperature difference between the overhead product (To) and the external reflux (T_e); (2) computes internal reflux flow rate (R_i); and (3) holds it constant by adjusting external reflux flow rate for efficient fractionator operation.

Ball Bearing Adjustable Thrust Collar Tube Expanders are made for Tubes ¼" diameter and larger.
Recommended for use with any Controlled Rolling Motor for uniform expansion of Tubes.

See your Dealer or write us for Bulletin.

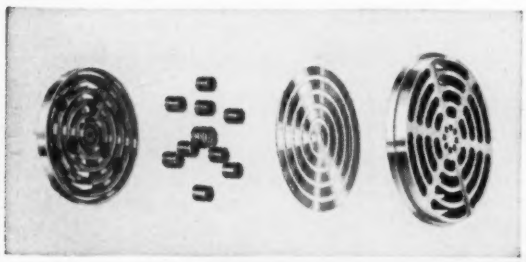
For Rolling—Heat Exchanger, Condenser and other Heat-Transfer Tubes.



THE GUSTAV WIEDEKE COMPANY
DAYTON 1, OHIO

VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



- up to 40% more valve area
- minimum pressure loss
- higher efficiency
- less power consumption
- normal discharge temperature
- quiet, vibration-free
- utmost safety
- lower operating costs

For detailed proposal send name, bore, stroke and speed of machine.

J.H.H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

New Equipment . . .

dimensions on most applications. Miniaturization of components and total elimination of external valving formerly required have enabled the company to solve the space and cost problems that once prevented the extensive use of hydraulic valve actuators. Oil-Dyne, Inc.

Circle E16 green card, last page

Cathodic Protection Anode Is Low-Cost Wire Type

A new form of anode, for cathodic protection systems using impressed current, is a composite conductor which combines the high-current-carrying ca-

pacity of copper, the anodic-passive properties of tantalum, and the non-sacrificial qualities of platinum. Because of its wire form and its unique combination of electro chemical properties, the ptc-clad anode makes possible the use of platinum for anodes which formerly would have been economically or technically impractical.

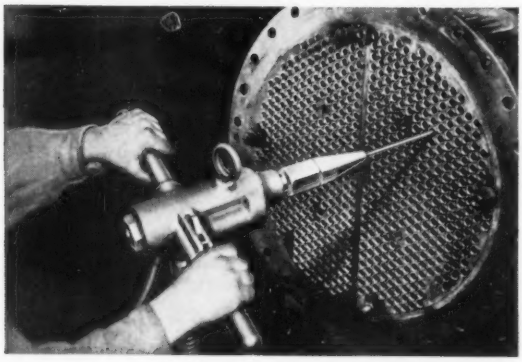
The anodes have a copper core with high electrical conductivity, surrounded by an impenetrable covering of tantalum. Platinum forms the outermost coating. The tantalum sheath, which has the property of unidirectional conductivity in an electrolytic medium, prohibits the transfer of electric current from the anode surface to the electrolytic environment except through those areas which are covered with the non-sacrificial platinum.

Among the many advantages claimed are ease of installation, low-installed cost, high current capacity and unusual flexibility in current distribution patterns. The anode is available in a size equivalent to the No. 10 copper wire conductor. Electro Rust-Proofing Corp.

Circle E17 green card, last page

KNOCK OUT SCALE
WITH
SUPER-POWERED
WILSON TUBE CLEANERS

Are your heat exchanger tubes completely fouled with scale buildup? Or, are you looking for that last vital inch of heat transfer efficiency? In either case, efficient, hard-working Wilson Tube Cleaners are the answer.



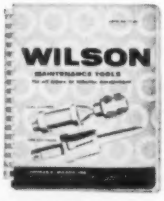
For heavy duty service, for example, use Wilson air driven Model TP 301 shown above. This super-powerful, 15 lb, light weight, scavenger-type tube cleaner drills and simultaneously flushes out deposits. It is suitable for vertical or horizontal use in straight tubes 3/8" ID to 2 7/8" ID and up to 40' long. Cleans rapidly and thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi. Other Wilson Cleaners are available for every tube size.

WILSON SUPER-DUTY CARBIDE BITS

TYPE M BIT
An inserted two-lip Helix type for general use.
1 1/32" to 1 19/32" bit OD.

TYPE K BIT
A two-lip Helix type with adaptor for general use.
1 1/4" to 2 3/4" bit OD.

TUBE EXPANDERS— Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into heavy tube sheets. Ball Bearing Collar Type 1/2" OD to 2 1/2" OD • **Write for your free copy of Wilson Catalog 77-88. It's a mine of information on tube cleaning and tube expanding problems.**



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THOMAS C. WILSON, INC.
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WILSON TW-899
BETTER TOOLS FOR BETTER WORK

PLIDCOFLANGE
PLIDCOFLANGE
PLIDCOFLANGE

...NO OTHER PIPE FITTING DOES SO MANY JOBS SO WELL

Designed for fast, easy installation plus economy

Plidcoflange applications are practically limitless. This versatile pipe fitting may be welded permanently to the pipeline, without shutting down, or bolted in place for future removal.

Plidcoflange slips over end of pipe, mates up with standard flange facings. No flange spreaders, jacks or bars required. Ideal for use as a blind plate flange. Just slide Plidcoflange back to change plates.

Plidcoflanges are available in standard sizes 2" through 12" with 150 lb. A.S.A. steel flanges. Other sizes and pressure classes on request. Send for illustrated brochure.

THE PIPE LINE DEVELOPMENT CO.
5700 DETROIT AVENUE CLEVELAND 2, OHIO
REPRESENTATIVES THROUGHOUT THE WORLD
Manufacturers of WELD+ENDS, SMITH SPLIT-COUPLING, SMITH SPLIT-SLEEVE SMITH+CLAMP and other products for the pipeline industry

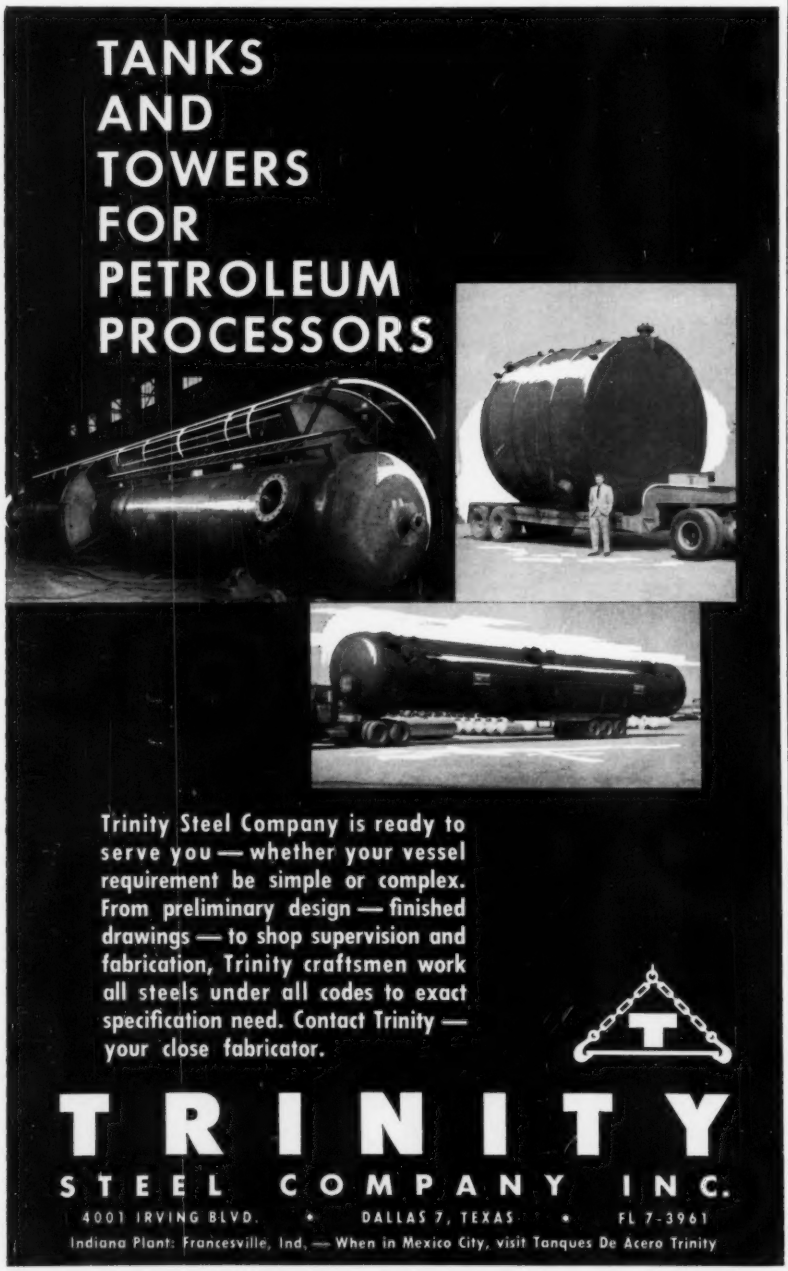
New Equipment . . .

Vinyl Coating Provides Higher Dry Film Thickness

A new high build vinyl coating, No. 99, has been developed for application with either conventional or airless spray equipment. The new coating is not a mastic, yet it overcomes the application disadvantages of most vinyls, which require multiple coats to achieve minimum protective thickness. As a result, substantial savings are being obtained on material and labor required to provide lasting protection against chemical and petroleum corrosion.

When applied with airless spray equipment, only one cross-sprayed coat of No. 99 is required to obtain a dry film thickness of more than 5 mils. Using conventional spray equipment, only two coats are required to produce a dry film thickness of 5 mils. Handling characteristics are excellent; the coating barely sags even with a wet film thickness of 25 mils. Amercoat Corp.

Circle E18 green card, last page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Trinity Steel Company is ready to serve you — whether your vessel requirement be simple or complex. From preliminary design — finished drawings — to shop supervision and fabrication, Trinity craftsmen work all steels under all codes to exact specification need. Contact Trinity — your close fabricator.
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4001 IRVING BLVD. • DALLAS 7, TEXAS • FL 7-3961
Indiana Plant: Francesville, Ind. — When in Mexico City, visit Tanques De Acero Trinity

Ball Valve Design Based On ID of Standard Pipe

Designed around the inside diameter of standard pipe, the new line of 3-inch through 6-inch full-port, bubble-tight ball valves are offered in many materials and are manufactured in both the 150-pound and 300-pound series. Nonstandard flanged valves are available as special items.

The full port in the valve's sphere is as free and open as the pipe the valve fits. This sphere is sealed with dual compressive seats which are filleted for longer wear and precision engineering has resulted in lower torque. The valve requires no lubrication.

Pressure or vacuum can be handled in either direction. Remote control operators can be supplied on the valves for plants using automation. The J. L. Putnam Co., Inc.

Circle E19 green card, last page

Selection Method Offered For Screw-Type Pumps

IMO rotary screw-type pumps for petroleum and process industries, power hydraulics, fuel, lubricating oil, and seal oil applications, viscous and fire-resistant fluids, are discussed in a 42-page bulletin. The pamphlet includes a selection guide, specifications, tables of performance data, tables of dimensions, viscosity tables and other general information. Advantages of the unique IMO design are covered, including high-speed, quiet operation, no need for timing gears nor bearings, high suction lifts, non-pulsating flow, reliability, adaptability, pressures to 3,000 psi, flows to 4,000 gpm. De Leval Steam Turbine Co.

Circle E20 green card, last page

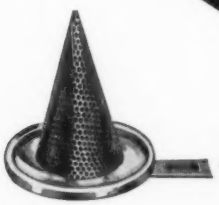
Specifications for Ductile Iron Gate Valves Given

A 12-page brochure covers the company's new line of gate valves designed specifically for ductile iron.

The new brochure describes both the Pipe-Pal series of ½-inch through 2-inch small gate valves featuring spiral-wound gaskets and a unique spread flange design," and the Pipe-Mate series of 2-inch through 12-inch large gate valves incor-

LITTLE TAG . . . BIG MEANING!

Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*



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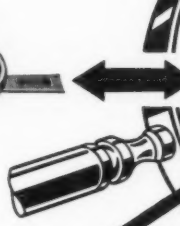

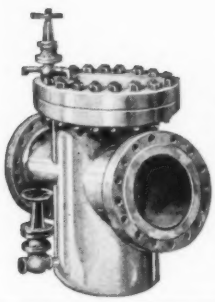

MAC-IRON CATALOG A-9

Although you'll find our full line Catalog A-9 in the current REFINERY CATALOG wouldn't you like more copies for distribution among your important engineering personnel?

Your request will bring all the copies you need.

WRITE TODAY . . .

THE MACK IRON WORKS COMPANY

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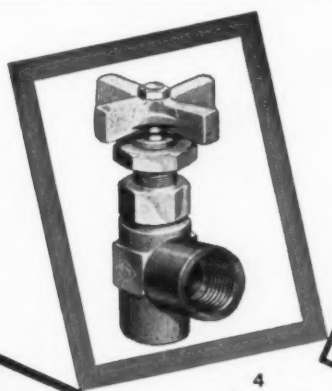
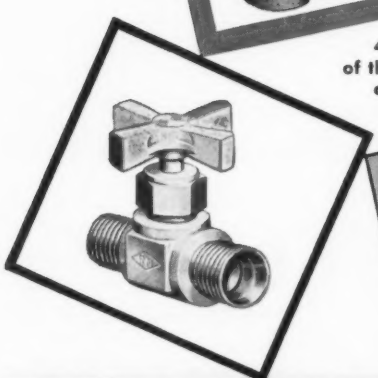
SPECIALISTS TO PETRO-CHEM-REFINING AND CHEM-PROCESS INDUSTRIES SINCE 1901

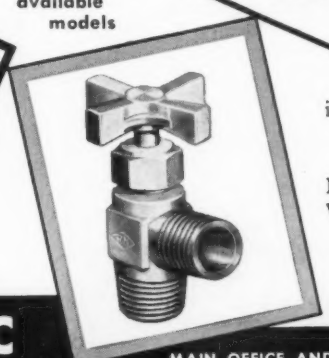
Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

BLINDS • SPACER RINGS • STRAINERS • SPECTACLE FLANGES

HIGH QUALITY at LOW COST!







4 of the 20 available models

NEW . . . *INSTRU*-NEEDLE VALVES

Republic Instru-Needle Valves are better, and cost no more. They give unexcelled service in instrumentation, gage shut-off, test panels, and other small-line circuitry. Economical to install and maintain. Standard units have 10 different porting combinations — inline and angle, with internal and external pipe, 37° flared, and flareless tube. All are standard in regular and panel-mounting types.

Bodies are forged, either brass or stainless steel. Working pressures: brass, 3000 psi; stainless steel, 5000 psi. For complete information, ask for Bul. 959.

Stocking Distributors Coast to Coast 317

REPUBLIC MANUFACTURING CO.

MAIN OFFICE AND FACTORY
15655 Brookpark Road, Cleveland 35, Ohio

PACIFIC SALES DIVISION
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DURA PLASTIC

STYLE B-77 GENERAL PURPOSE PACKING

B-77 SPIRAL PACKING FEATURES:

★ Contains long asbestos fibers, lead shreds, graphite and binders
★ Remains uniform in shape under compression
★ Resilient — yields easily to gland adjustments
★ Does not "dry-out" or deteriorate in stock
★ Also available in die-molded rings (Type B-777)

FOR STUFFING BOXES on pumps, valves, mixers and the like for GASOLINE-AIR-STEAM OILS AND MILD CHEMICALS AND ACIDS UP TO 500°F.

WRITE FOR BULLETIN NO. 402-PR

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Where control depends on measurement!

CON-O-PAK THERMOCOUPLES

FROM -300°F TO 4000° PLUS

The world's finest thermocouples. New process increases precision and temperature range. Exceeds all military and commercial specs. Con-O-Pak is used in aircraft, missiles, nucleonics, chemical processing. Useful data? . . . Ask for "The Con-O-Pak Story."

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FLEXIBLE AND SHEATHED THERMOCOUPLES • THERMOCOUPLE WIRE • HEATING ELEMENTS • CONNECTORS

New Equipment . . .

porating a new and stronger "buttressed flange" construction.

In addition to listing complete engineering specifications, pressure-temperature ratings, and testing data, the folder describes many applications for ductile iron valves. Included also is a description of the engineering properties of ductile iron and the advantages it offers in the valve field. The Ohio Injector Co.

Circle E21 green card, last page

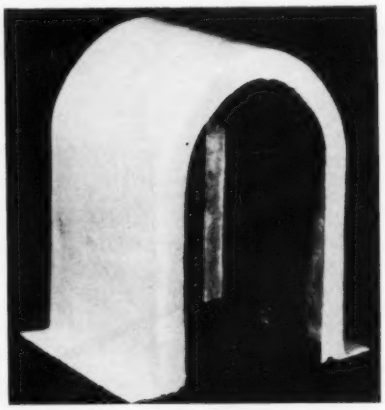
"Half A Man Is Not Enough" Covers Over-Specialization

A new 12-page booklet titled, "Half a Man is Not Enough," discusses the problem of over-specialization by engineers with its resultant lack of development in the fields of human interests and understanding. It points out that human interests must balance technical efficiency before an engineering specialist can really be on the road to success and happiness. The booklet also contains a 14-point check list which may be used as the basis to develop a formula for well-rounded, successful living. Western Supply Co.

Circle E22 green card, last page

Epoxy Pump Coupling Guard Never Needs Painting

A new pump coupling guard, made from glass reinforced polyester resin or epoxy is corrosion-resistant, strong and

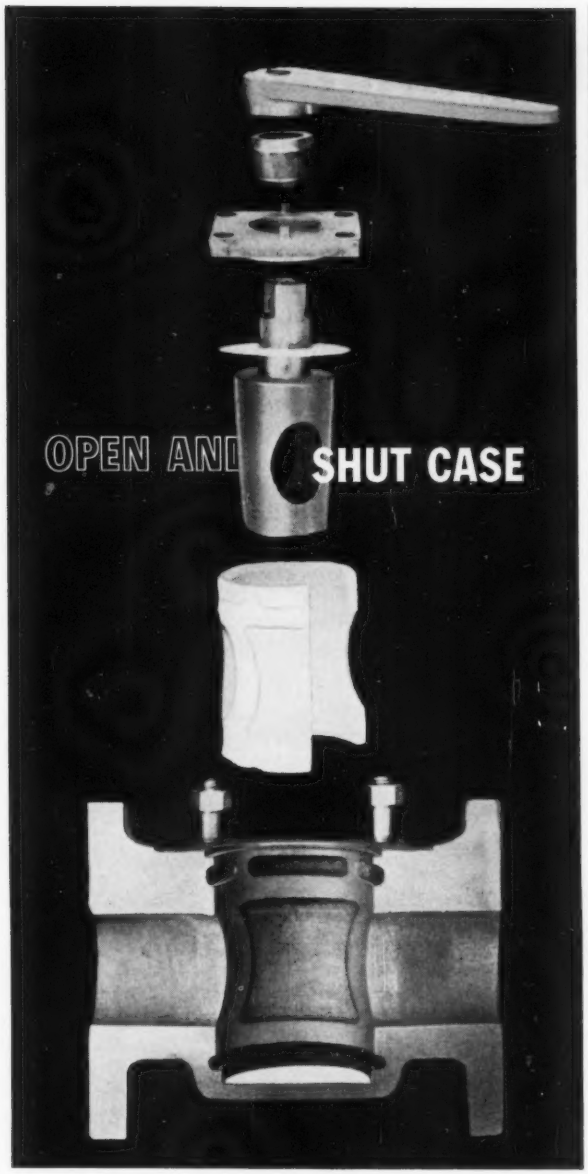


durable. It has approximately one-third the weight of steel. Color is blended in the resin, and painting the guards is unnecessary. Four standard sizes are available. Armadillo Plastics Co.

Circle E23 green card, last page

Bulletin Gives Detailed Lubrication Instructions

An eight-page bulletin providing complete instructions for lubricating and servicing lubricated valves describes by



Leakproof sealing without maintenance in ON-OFF service makes an open and shut case for specifying Continental's TUFLINE non-lubricated plug valves. ■ For the facts of the case, examine closely the special high pressure sealing ribs and carefully sculptured body bore configuration. This, combined with the specially tempered pure Teflon* sleeve and tapered plug, is where Tufline valves pay off... in bubble-tight sealing without plug adjustment even under fluctuating temperature conditions. ■ For complete information on Tufline valves ¼" through 10", 150# and 300# class, 2-way through 5-way, or jacketed, furnished in a wide range of metals for services from light hard-to-hold gases to heavy corrosive slurries, temperatures –150° F. to + 400° F., high vacuum to 615 psi (depending on temperature), write Continental Mfg. Co., 230 Park Ave., New York 17, N.Y. *Registered trademark of E. I. Dupont de Nemours & Co., Inc.

TUFLINE PLUG VALVES

CONTINENTAL MANUFACTURING COMPANY • CINCINNATI 42, OHIO

So SIMPLE
We Can
Adapt It
to ANY
LIQUID LEVEL
CONTROL JOB
A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.
MAGNETROL

AS DEPENDABLE AS MAGNETIC FORCE ITSELF

● No matter how specialized the liquid level control application, adapting Magnetrol to meet it presents no problem. Whether it's for high pressures, high temperatures, corrosive liquids or any other condition, a few "standard" modifications and the job is done! Operation is so simple no changes in basic design are needed. That's why Magnetrol "fits" practically any application — why "specials" are so often standard with us.

Because of the utter simplicity and dependability of its magnetic principle, Magnetrol has *infinite operating life.* There are no wearing parts to get out of order.

Magnetrols are available for controlling level changes from .0025-in. to 150-ft., with single or multi-stage switching. Our experienced engineering staff is at your service.

MAGNETROL, Inc.

WHY NOT MAIL THE COUPON — NOW

MAGNETROL, Inc., 5312 Belmont Rd., Downers Grove, Ill. 7
Please send me catalog data and full information on Magnetrol Liquid Level Controls.

Name_____

Company_____

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For more data on advertised products, use Readers' Service Cards, last page.

Servo Power satisfies more

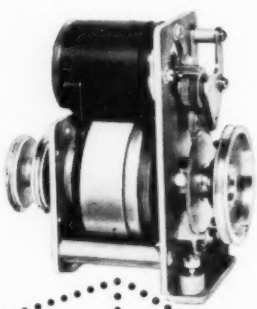
in Taylor TRANSCOPE® Electronic and Pneumatic

Powerful SERVOMATIC motors in Taylor TRANSCOPE Recorders not only give you greater recording accuracy than ever before, they also supply the power necessary for precision operation of auxiliary mechanisms and computing devices. Power in the pneumatic servo is 150 times greater than the bellows type; in the electronic it's 1,000 times greater than galvanometer systems.

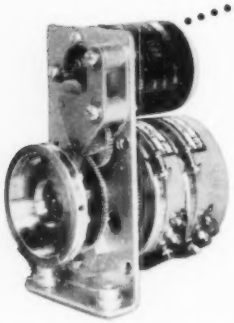
This means closer measurement of temperature, pressure, flow, flow ratios, pH and other process variables—whether the signals are pneumatic or electric. Accuracy of ½ of 1% is standard, ¼ of 1% optional.

You economize with servo power because you no longer need conventional "black boxes" for auxiliary functions. You save on panel space . . . and installed cost.

Optional features made possible by servo power include integral process alarms, retransmitting potentiometers, function generation and digital output with encoder discs. Ask your Taylor Field Engineer to demonstrate the built-in plus value of servo power in the TRANSCOPE line. Or write for **Bulletin 98286** (Pneumatic) or **98335** (Electronic). Taylor Instrument Companies, Rochester, New York, or Toronto, Ontario.

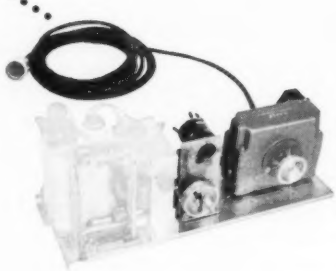


700J ELECTRONIC SERVO MOTOR
Precision gearing couples servo to a precise feed-back device with high torque. Built to military specifications.



RETRANSMITTING POTENTIOMETER
permits numerous computations such as $_{xy}$, $\frac{x}{y}\frac{xy}{z}$, $\sqrt{x}$.

INTEGRAL ALARMS
cost approximately 1/3 as much as conventional external "black boxes".

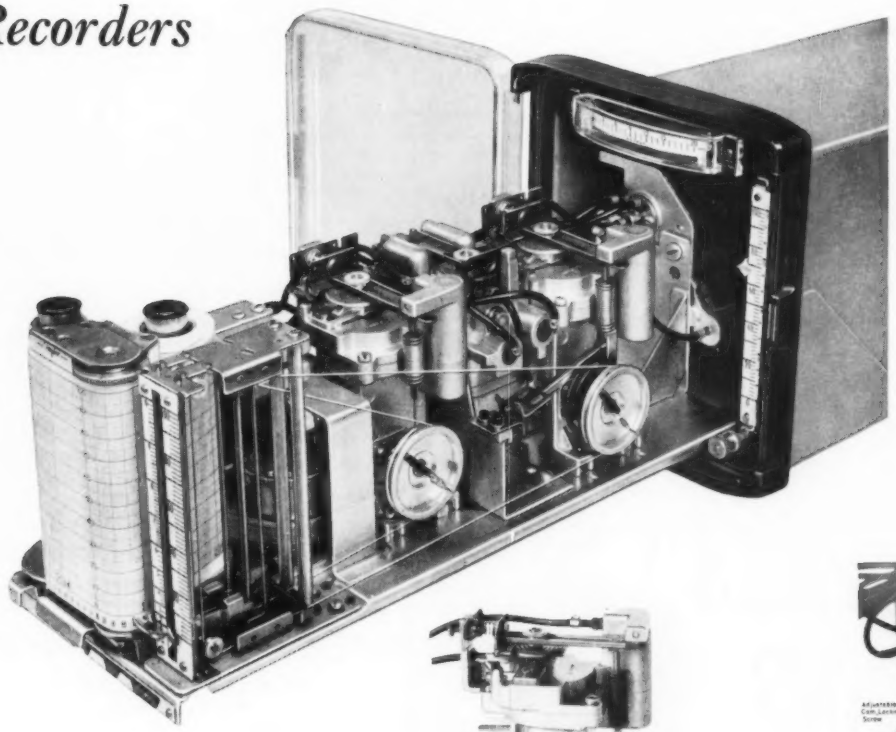


DIGITAL ENCODER
—servo motor permits use of compact, high accuracy, integral encoders.

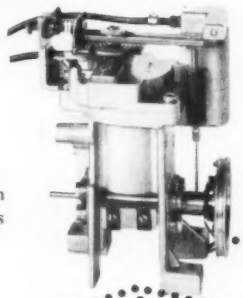
Taylor Instruments

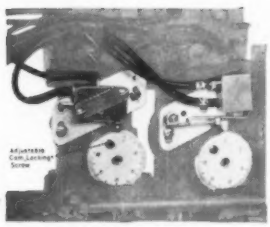
process needs *more economically*

Recorders

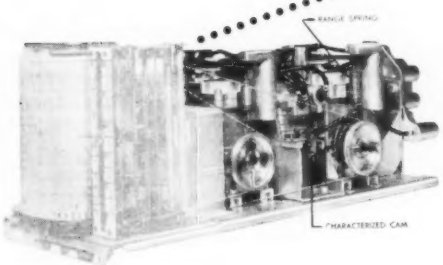


90J PNEUMATIC SERVO MOTOR
Essentially a power piston with built-in positioner. Solid construction assures long, trouble-free life.

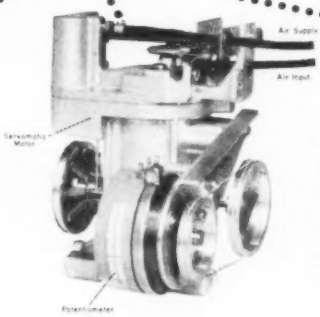




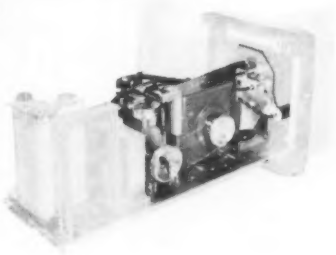
INTEGRAL ALARMS
Alarm points convenient to set on calibrated dials.



FUNCTION GENERATOR
puts square root extraction and other similar functions within recorder.



POTENTIOMETER
costs about half as much as usual "black box" transducers.



DIGITAL ENCODER
sets new standards of accuracy for pneumatically driven encoders.

MEAN ACCURACY FIRST

For more data on advertised products, use Readers' Service Cards, last page.

text and step-by-step illustrations the proper method of lubrication for all the types of the company's lubricated plug valves, the correct adjustment of valves; how to repack Hypreseal valves with plastic stem packing, etc.

The bulletin also includes a chart of recommended lubricants and photos and description of the company's lubricant dispensing equipment. Rockwell Manufacturing Co.

Circle E24 green card, last page

ASME Pressure Vessel Code References on Wall Chart

A handy wall chart titled "Quick Reference Guide to ASME Boiler and Pressure Vessel Code (Section VIII) has been prepared to illustrate some of the types of pressure vessel construction provided for under Section VIII of the ASME Code, and to furnish direct references to the code rules that apply to these construction features.

Thus, for example, circumferential joints are illustrated along with the suggestion to refer to code rules UW-34 and UW-35 for a full discussion of such joints. Missouri Boiler and Tank Co.

Circle E25 green card, last page

ONE PUMP FILLS TIN CANS OR TANKERS

Vari-Flo changes capacity instantly

Do you have pumping jobs that vary from a "dribble" to a "gusher"? Then, you should learn about the new Blackmer Vari-Flo . . . the variable-capacity pump that just might do the job several pumps are doing for you now. The Vari-Flo is much like the Blackmer vane-type rotary pumps you know about, but it has the important addition of a dial-operated "flow changer" that varies the capacity of the pump. Does it with an ordinary standard motor, too . . . no costly variable-speed drive is needed. Whether you're filling a tin can or a tanker, you can dial the proper flow rate as easily as phoning your Blackmer distributor. Which, by the way, is a very good idea if you see a chance for an application.
Or, write for Bulletin 600.

"liquid materials handling"® equipment

BLACKMER / vari-flo pumps

BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICHIGAN

Find your Blackmer Man under "Pumps" in the Yellow Pages

Corrosion Problems, Proper Coatings Listed

The solution to a wide variety of corrosion and deterioration problems is presented in the new eight-page bulletin on bitumastic cold-applied protective coatings.

In addition to covering the properties and specification data on nine major products, the brochure lists scores of typical installations requiring corrosion protection along with the recommended bitumastic coating to assure lasting protection. Koppers Co., Inc.

Circle E26 green card, last page

Centrifugal Pump Catalog Includes Selection Guide

A new 12-page selection catalog for users of centrifugal pumps includes easy-to-use charts showing the recommended temperature and pressure ranges for 10 classifications of the company's pumps—from minus 350° F to plus 1,000° F, and up to 1,000 psig. Illustrations, brief descriptions and specifications are shown for each. Dean Brothers Pumps, Inc.

Circle E27 green card, last page

Valve Actuator Application Discussed in 16-Page Book

A 16-page engineering data book on valve motorization entitled "Type RX Servo-Motor for Remote Control of Valves" presents a complete presentation of basic technical information on valve actuator applications with special emphasis on remote installations and operation of the number of valves in-series SADI.

Circle E28 green card, last page

Electrostatic Precipitator Selection Covered in Paper

Copies of a recent talk on electrostatic precipitators, by the company's chief electrical engineer, Lester L. Nagel, discusses what the plant engineer should know about the requirements of an electrostatic precipitator for industrial applications. Buell Engineering Co., Inc.

Circle E29 green card, last page

Demister Brochure Covers HPI Entrainment Problems

A technical catalog brochure on Demisters used in hydrocarbon processing operations includes a discussion of the entrainment problem and the function of the Demister. Also included are graphs and other technical information. L. N. Mills & Co., Ltd.

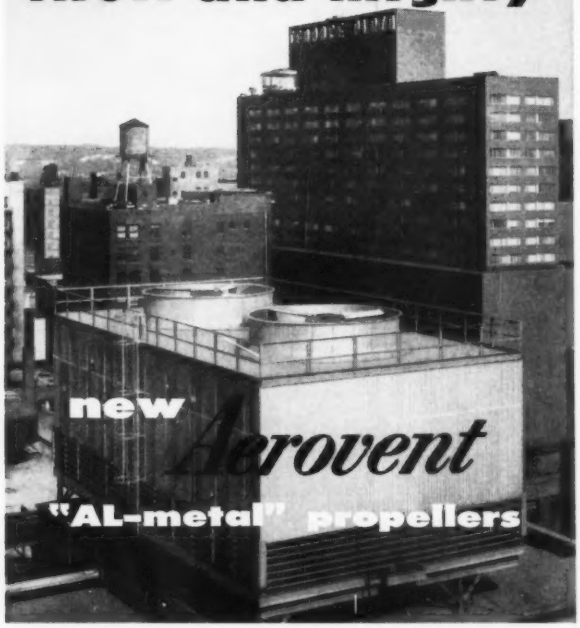
Circle E30 green card, last page

48-Page Catalog Features Multipoint Recorders

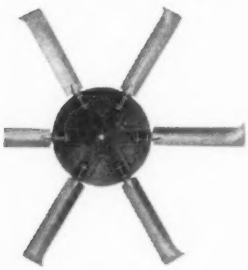
A new 48-page recorder catalog highlights new modular design features, the quick-changing 2 to 24 point ElectroniK Universal Multipoint recorder, and other strip and circular chart recorders and precision indicators. Minneapolis-Honeywell Regulator Co.

Circle E31 green card, last page

"HIGH and mighty"



move mountains - of AIR!
in towers and exchangers



- Sizes 14' to 18'
- 4 or 6 blades

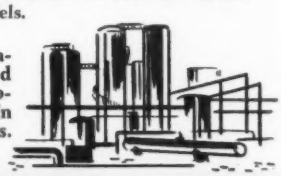
Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

Write for free Bulletin 510

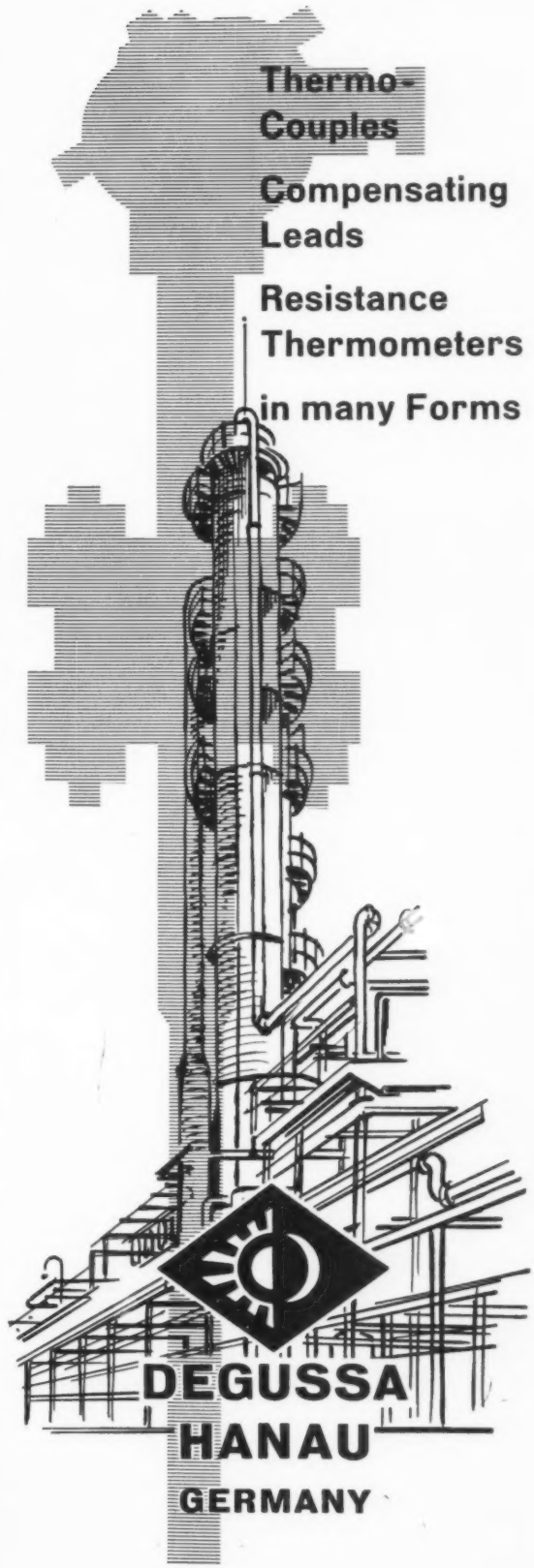
DESIGNED FOR DEPENDABLE OPERATION!

Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in Adjustable Pitch Models.

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.



Aerovent FAN COMPANY, INC.
LARGE PROPELLER DIVISION
304 Wright Bldg.
TULSA 3, OKLA.
Main Office and Factory
PIQUA, OHIO



Advertisers in This Issue

*The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1960 Refinery Catalog.

A

*ACF Industries, Inc.
W-K-M Division 55
*ADSCO Division
Yuba Consolidated Industries, Inc. 271
*Aerovent Fan Co.
Large Propeller Division 303a
*The Air Preheater Corp. 259
*Airetool Manufacturing Co. 252
Allied Chemical Corp.
General Chemical Division 171
Allied Chemical Corp.
Solvay Process Division 97
Alloy Steel Products Co. 283
The Allpax Co. 255
*Aluminum Company of America 50
Amercoat Corp. 270
American Bitumuls & Asphalt Co. 248
American Brake Shoe Co. 230
American Cyanamid Co.
Refinery Chemicals Dept. 82
American Pipe & Construction Co. 32
Ampco Metal, Inc. 234
*The V. D. Anderson Co. 280
*Anemostat Corporation of America 250
Armite Laboratories 273a
*Armstrong Machine Works 242
Associated Electrical Industries Export Ltd. 36B
*Audley Engineering Co. Ltd. 36L

B

B-I-F Industries, Inc. 2
Babbitt Steam Specialty Co. 288b
*The Babcock & Wilcox Co. 67
The Babcock & Wilcox Co.
Tubular Products Division 11
Badger Manufacturing Co. 268-269
*Bailey Meter Co. 100
*Barco Manufacturing Co. 232
Beckman Instruments, Inc. 91
The Bendix Corp.
Cincinnati Division 68b
Bethlehem Steel Co. 84
Betz Laboratories, Inc. 40-41
Blackmer Pump Co. 302
Bonney Forge & Tool Works 225
*Borden Metal Products Co. 275
*Bridgeport Brass Co. 245
The Bristol Co. 98
British LaBour Pump Co. Ltd. 36G
Ralph N. Brodie Co. 25
Brown & Root, Inc. 59
*Brown Fintube Co. 237
*Buell Engineering Co. 8
*Buffalo-Eclipse Corp. 266

C

*Calumet & Hecla, Inc. 239-240
*Camco Fittings, Inc. 197
*Cape Insulation & Asbestos Products Ltd. 37
Carter-Waters Corp. 273c
Catalytic Construction Co. 39
*Catawissa Valve & Fittings Co. 262
*Causeway Reinforcement Ltd. 36D
Celanese Chemical Co.
Div. Celanese Corporation of America 104
*Chiksan Co. 101
Chiyoda Chemical Engr. & Construction Co. Ltd. 86
Cincinnati Division
The Bendix Corp. 68b
*Clark Bros. Co.
One of The Dresser Industries 48-49
*The Cleveland Wire Cloth & Mfg. Co. 284a
*Colorado Oil and Gas Corp. 34
Conoflow Corp. 33
Continental Manufacturing Co. 299a
Continental Sensing, Inc. 298b
*The Cooper-Bessemer Corp. 78-79
*Coppus Engineering Corp. 45
Crane Co. 183
Crane Packing Co. 231

D

Darling Valve & Mfg. Co. 193
Dearborn Chemical Co. 71
DEGUSSA 303b
De Laval Steam Turbine Co. 64-65
Deloro Stellite Ltd. 36u
Dempster Brothers, Inc. 4
Diamond Electronics Division
Diamond Power Specialty Co. 204-205
*John L. Dore' Co. 102
Dow Industrial Service Division
The Dow Chemical Co. 87
*Dresser Industries, Inc. 48-49
*The Ducon Co. 253
E. I. du Pont de Nemours & Co. 35-36
Durametallic Corp. 298a

E

Eastman Chemical Products, Inc. 46
Electro-Alloys Division
American Brake Shoe Co. 230
*Elliott Co. 200
*Engineers & Fabricators, Inc. 206
Ethyl Corporation 16-17
Evershed & Vignoles Ltd. 36R

F

*Fisher & Ludlow Ltd. 36C
Fisher Governor Co. 51, 246
Flexonics Corp. 207
The Foxboro Co. 62
Fram Corp. 60

G

*Gamewell Corp. 279
Gardner-Denver Co. 244
*Garlock, Inc. 229
*General American Transportation Corp. 75
General Chemical Division
Allied Chemical Corp. 171
General Electric Co. 83
General Kinetics Corp. 189
Glascote Products, Inc. 233
*Fritz W. Glitsch & Sons, Inc. 281
*Claud S. Gordon Co. 241
*Goulds Pumps, Inc. 276
*Graham Manufacturing Co. 208
Gray Company, Inc. 203
Gray Tool Co. 289
*Grinnell Co. 224
Groban Supply Co. 288d
*Gulf Publishing Co. 36Vb
Gulf States Tube Corp. 6

H

Hagan Chemicals & Controls, Inc. 58
*Hamer Valves 236
*The Harshaw Chemical Co. 263
*Hartzell Propeller Fan Co. 258
C. I. Hayes, Inc. 186
*Head Wrightson Processes Ltd. 36A
*Heliflow Corp. 208
*Houdaille Industries, Inc. 278
*Hudson Engineering Corp. 201
Humble Oil & Refining Co. 85

I

Imperial-Eastman Corp. 260-261
International Harvester Co. 287

J

*Jamesbury Corp. 221
Jenkins Bros. 28
*Jerguson Gage & Valve Co. 286a
Jerguson Tress Gage & Valve Co. Ltd. 36J
*Johns-Manville Corp. 264-265
Jomac, Inc. 227

K

Kaiser Refractories 247
Kano Laboratories 288a
*Keasbey & Mattison Co. 26
*The M. W. Kellogg Co. 12, 72-73
*Koch Engineering Co. 93
Koppers Co. 286b

L

*Lapp Insulator Co. 251
Layne and Bowler, Inc. 24
Leeds & Northrup Co. 21
Lenape Hydraulic Pressing & Forging Co. 284b
Warner Lewis Co.
Division Fram Corp. 60
LimiTorque Corp. 285
LimiTorque Valve Controls Ltd. 36F
Lukens Steel Co. 47
*The Lummus Co. 172

M

*The Mack Iron Works Co. 297a
*Magnetrol, Inc. 299b
*Manzel Division
Houdaille Industries, Inc. 278
*Marsh Instrument Co.
Division Colorado Oil and Gas Corp. 34
*Mason-Neilan Division
Worthington Corp. 194-195
Arthur G. McKee & Co. 187
Mechans Limited 36S
Metaducts, Ltd. 36P
Metal Propellers Ltd. 36Tb
Michigan Seamless Tube Co. 6
*Millspaugh Limited 36M
Minneapolis-Honeywell 22-23, 292-293
*W. K. Mitchell & Co. 43
*Mixing Equipment Co. 188
*Murray Iron Works Co. 226

N

Nalco Chemical Co. 27
Napko Corp. 96
Nederlandsch Verkoopkantoor voor Chemische Producten, N. V. 36E
*Nettco Corp. 185
New England Valve Corp. 177
Newalls Insulation Co. Ltd. 80
*W. H. Nicholson & Co. 277
*Norton Co. 99

O

*Oakite Products, Inc. 249
Orbit Valve Co. 63
*Samuel Osborn & Co. Ltd. 36N

P

Palmer Thermometers, Inc. 192
*Penberthy Manufacturing Co.
Division Buffalo-Eclipse Corp. 266
Pennsalt Chemicals Corp. 90
*Petreco Division
Petrolite Corp. 29
*Phelps Dodge Copper Products Corp. 18-19
Philadelphia Gear Corp. 285
*The Pipe Line Development Co. 295b
Plenty & Son Ltd. 36Va
*Plibrico Co. 228
The Pyrene Co. Ltd. 36K

R

*Ready Cool, Inc. 103
Redheugh Iron & Steel Co. Ltd. 36Ta
Reeves Brothers, Inc. 291b
*Refinery Catalog 52-53
Republic Manufacturing Co. 297b
*Republic Steel Corp. 256-257
The Ridge Tool Co. 68a
*Wm. L. Riggs Co. 273b
Robbins Aviation, Inc. 238
*Rochester Manufacturing Co. 235
Rockwell Manufacturing Co. 308
*Rockwood Sprinkler Co.
Division of Gamewell Corp. 279

S

SADI 196b
Sarco Co. 198
*Schutte & Koerting Co. 76
*Scovill Manufacturing Co. 69
*M. B. Skinner Co. 196a
A. O. Smith Corp.
Atomic and Process Equipment Div. 95
A. O. Smith Corp.
Sub. Glascote Products, Inc. 233
*Smithco Engineering, Inc. 243
Solar Aircraft Co.
Sub. International Harvester Co. 287
Solvay Process Division
Allied Chemical Corp. 97
*Southwestern Engineering Co. 272
Spee-Flo Mfg. Co. 290
Spraying Systems Co. 288c
Square D Company 74
Standard Oil Co. (New Jersey) 70
Stauffer Chemical Co. 30-31
The Stearns-Roger Mfg. Co. 14
Stockham Valves & Fittings 20
*Strahman Valves, Inc. 199b
*Stratford Engineering Corp. 44
*Strong, Carlisle & Hammond 191
*Sun Shipbuilding & Dry Dock Co. 89

T

*Taylor Instrument Companies 300-301
*Technical Oil Tool Corp. 77
*The Terry Steam Turbine Co. 92
*Thermal Research & Engineering Corp. 282
*Thermon Manufacturing Co. 199a
*The Timken Roller Bearing Co. 254
*Tretolite Co.
Division Petrolite Corp. 66
Trinity Steel Co. 296
Truland Chemical Co. 38
Tubular Products Division
The Babcock & Wilcox Co. 11

U

*Union Asbestos & Rubber Co. 34
United States Steel Corp. 267
*United States Stoneware Co. 88
*Universal Atlas Cement Division
United States Steel 267
Universal Oil Products Co. 56-57

V

*Henry Vogt Machine Co. 94
*Vokes Genspring Ltd. 36h
*J. H. H. Voss Co. 294b

W

*W-K-M Division
ACF Industries, Inc. 55
*The E. H. Wachs Co. 291a
Warren Petroleum Corp. 223
Weir-Pacific Valves Ltd. 36q
Well Equipment Mfg. Corp. 236
*The Gustav Wiedeke Co. 294a
*A. R. Wilfley & Sons, Inc. 42
T. D. Williamson, Inc. 202
*Thomas C. Wilson, Inc. 295a
*Wolverine Tube Division
Calumet & Hecla, Inc. 239-240
*Worthington Corp. 81, 194-195
Wyatt Industries, Inc.
Wyatt Metal & Boiler Works Division 307

Y

*Yarnall-Waring Co. 61
*Yuba Consolidated Industries, Inc. 271

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E1	E2	E3	E5	E6	E7	E8	E9	E10	E11	E12
E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23
E24	E25	E26	E27	E28	E29	E30	E31	E32	E33	

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2	4	6	8	11	12	14	16—17	18—19	20	21	22—23	24	25	26	27	28		
29	30—31	32	33	34	35—36	36A	36B	36C	36D	36E	36F	36G	36H	36J	36K	36L	36M	
36N	36P	36Q	36R	36S	36Ta	36Tb	36U	36Va	36Vb	37	38	39	40—41	42	43	44	45	46
47	48—49	50	51	52—53	54	55	56—57	58	59	60	61	62	63	64—65	66			
67	68a	68b	69	70	71	72—73	74	75	76	77	78—79	80	81	82	83	84	85	
86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	171
172	177	183	185	186	187	188	189	191	192	193	194—195	196a	196b	197	198	199a	199b	200
201	202	203	204—205	206	207	208	221	223	224	225	226	227	228	229	230	231	232	233
234	235	236	237	238	239—240	241	242	243	244	245	246	247	248	249	250	251	252	253
254	255	256—257	258	259	260	261	262	263	264—265	266	267	268—269	270	271	272	273a		
273b	273c	275	276	277	278	279	280	281	282	283	284a	284b	285	286a	286b	287	288a	288b	288c
288d	289	290	291a	291b	292—293	294a	294b	295a	295b	296	297a	297b	298a	298b	299a	299b	300—301		
302	303a	303b	307	308														

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PETROLEUM REFINER Readers' Service Card — **Jan., 1961, Issue***

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E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23
E24	E25	E26	E27	E28	E29	E30	E31	E32	E33	

ADVERTISEMENTS—Circle page number of ad for more products information:

2	4	6	8	11	12	14	16—17	18—19	20	21	22—23	24	25	26	27	28
29	30—31	32	33	34	35—36	36A	36B	36C	36D	36E	36F	36G	36H	36J	36K	36L	36M
36N	36P	36Q	36R	36S	36Ta	36Tb	36U	36Va	36Vb	37	38	39	40—41	42	43	44	45	46
47	48—49	50	51	52—53	54	55	56—57	58	59	60	61	62	63	64—65	66			
67	68a	68b	69	70	71	72—73	74	75	76	77	78—79	80	81	82	83	84	85	
86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	171
172	177	183	185	186	187	188	189	191	192	193	194—195	196a	196b	197	198	199a	199b	200	
201	202	203	204—205	206	207	208	221	223	224	225	226	227	228	229	230	231	232	233	
234	235	236	237	238	239—240	241	242	243	244	245	246	247	248	249	250	251	252	253	
254	255	256—257	258	259	260	261	262	263	264—265	266	267	268—269	270	271	272	273a			
273b	273c	275	276	277	278	279	280	281	282	283	284a	284b	285	286a	286b	287	288a	288b	288c
288d	289	290	291a	291b	292—293	294a	294b	295a	295b	296	297a	297b	298a	298b	299a	299b	300—301		
302	303a	303b	307	308															

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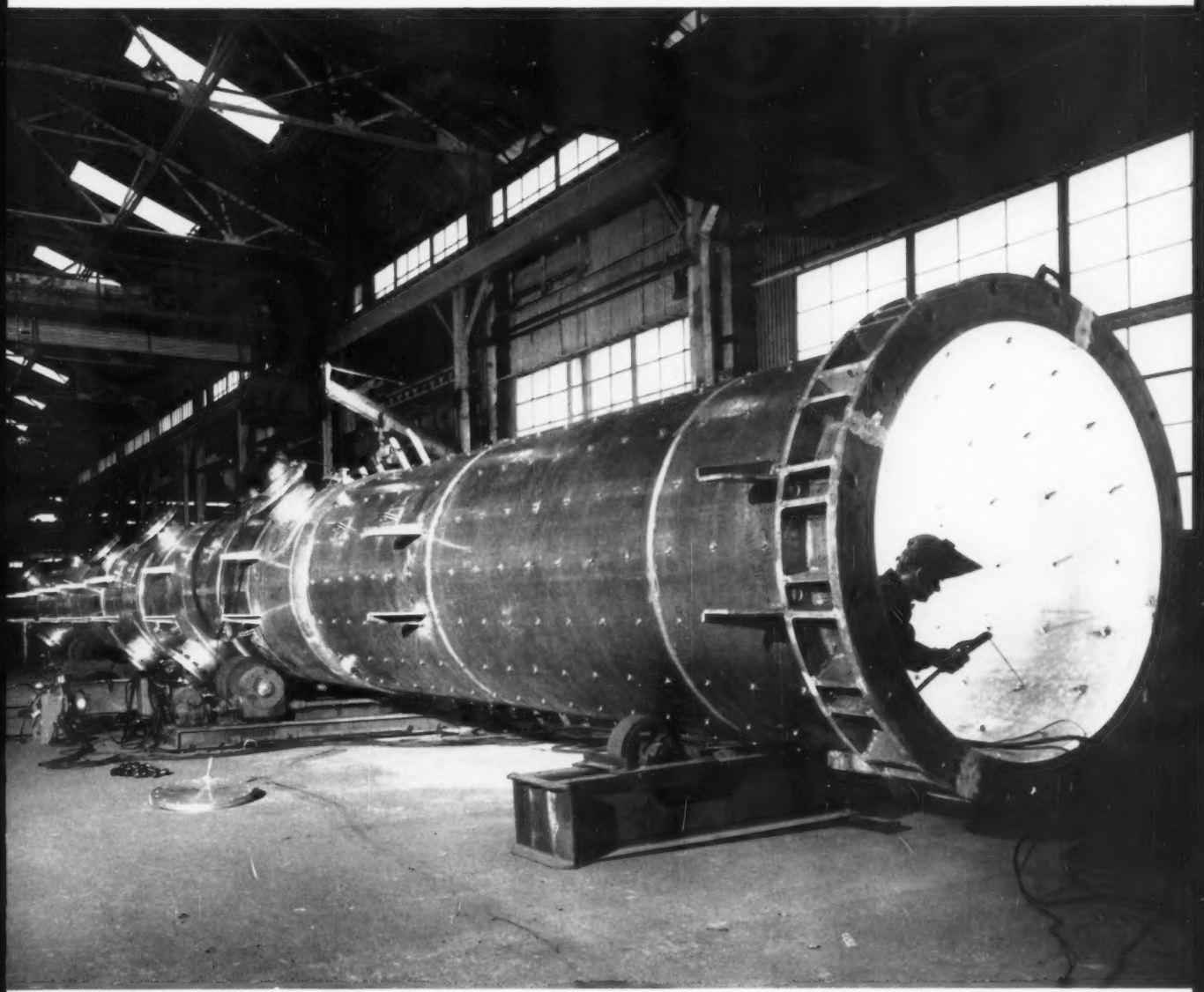

Solid aluminum urea stripper tower being completed in Wyatt's Dallas shops.

Wyatt's
HOUSTON - DALLAS
CORPUS CHRISTI - MEXICO CITY

MANUFACTURERS AND ERECTORS SINCE 1913

WYATT INDUSTRIES, INC.

Sales Offices: Houston • Dallas • Corpus Christi • Tulsa
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Wyatt de Mexico S. A. de C. V.
Mexico City, Mexico

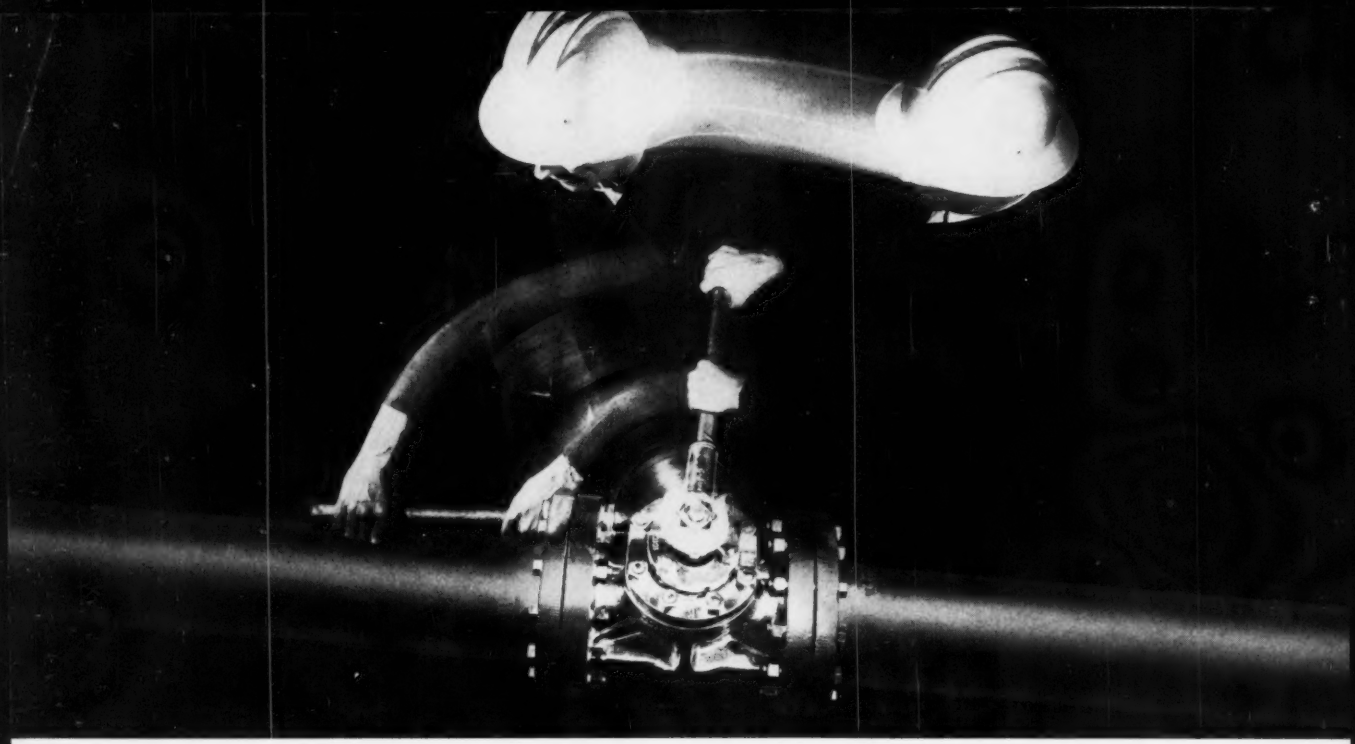
PLASTIC AND RUBBER DIVISION

Plants: Houston and Wallis

LICENSEES OF WYATT'S FLOATING ROOFS

FISHER TANK COMPANY
Third and Booth Streets
Chester, Pennsylvania

PETRO-FOUGA
111 Avenue Victor-Hugo
Paris (16E) France



Stroboscopic photo shows fast, smooth quarter turn closure of Rockwell-Nordstrom lubricated plug valves.

THESE LUBRICATED VALVES CLOSE 2 TO 5 TIMES FASTER

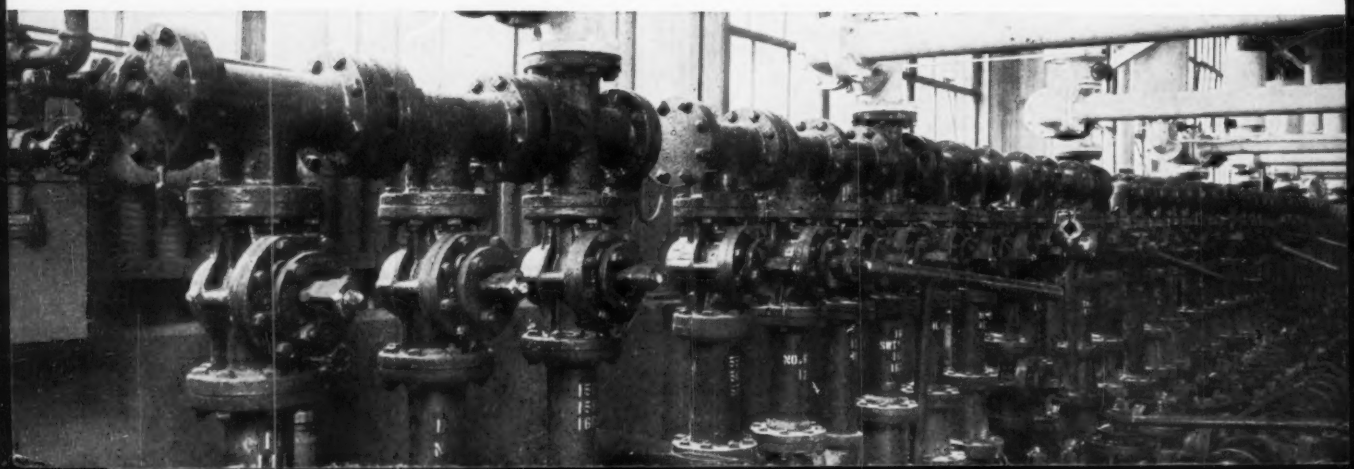
Rockwell-Nordstrom *lubricated* plug valves save time, reduce flow control errors because they close quickly, positively and easily with just a quarter turn. One man can open or close a dozen of these valves in the time it takes to laboriously wrestle one hand wheel on other types of valves.

Faster closure isn't the only advantage of Rockwell-Nordstrom lubricated plug valves. Their Sealdport pressurized lubrication system insures positive shut-off by creating powerful seals of hydraulically energized lubricant at the seat ports. And, isn't it just common sense that any lubricated mechanism will work better, longer and at far lower cost than a "dry" one? Get complete details on Rockwell-Nordstrom lubricated plug valves (the world's most complete line) by writing: *Rockwell Manufacturing Company, Pittsburgh 8, Pa.; Canadian Valve Licensee, Peacock Brothers Limited; Rockwell International S.A., Geneva, Switzerland.*

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

One man can open or close this refinery transfer manifold 3 times faster than three men winding handwheels on ordinary valves.